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Science & Technology China

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Taiwan State High Speed Computer Center

94080172A Taipei K'OHSEH FACHAN YUEK'AN
[NATIONAL SCIENCE COUNCIL MONTHLY]
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[Article by Chang Shancheng [1728 0810 2398], High Speed Computer Center]

[FBIS Translated Text]

1. Introduction

High speed computation is the new technology for applied S&T, industrial development and academic research. To respond to the needs of domestic high speed S&T development and academic research, and under the orders and approval of the Executive Yuan, in 1991, National Science Council specifically set up state high speed computer center. The purposes of setting up a state high speed computer center are:

- (1) To relieve the bottleneck of insufficient computer resources available for domestic cutting-edge research;
- (2) To promote the application of high speed computation in governmental organizations and the industrial sector in order to raise the level and effectiveness of major national construction and industrial R&D;
- (3) Through application of high speed computation, bring about the needed free interflow between the resource and information specialties and the user domain, and promote thorough interdisciplinary research.
- (4) To encourage, through purchases of large-scale facilities, the importation of foreign high speed computer know-how and key intellectual skills, to bring domestic applications more quickly up to the international level.
- (5) To establish a high value-added applied software program repository that will meet the needs for applied software for R&D in the academic and industrial sectors, and then stimulate the development of the applied software industry.

2. Organization and facilities

- (1) The state high speed computer center is one of the five major state laboratories, which has one director, two deputy directors and three subordinate teams for hardware and software management, promotion of research, and administration. The hardware and software management team is mainly responsible for planning, management and maintenance of hardware and software systems; the research promotion team aims to provide users with needed consultation services and research, and also to promote the application of high speed computers; the administration team is responsible for various kinds of coordination work. As the research load increases in future, an R&D team will be considered.

(2) Hardware and Software

Facilities in the center located at the Hsinchu Science Park are listed below, and users would only need access to the Taiwan academic network to work directly from their offices, laboratories, or even their homes to use these facilities.

Hardware facilities:

(1) Supercomputer mainframe (IBM ES9021/86)

The mainframe has five central processing units (CPU), each with vector processors, main memory unit 512MB, extended memory unit 2GB, and magnetic disk 112GB.

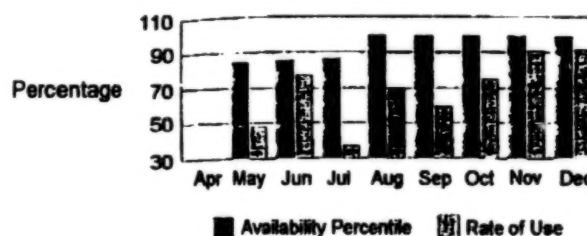
The monthly operational status of the supercomputer mainframe after installation in April is listed below:

Month	Availability Rate	Using Rate
April	Installation Completed	Installation Completed
May	84.74 percent	47.96 percent
June	85.70 percent	77.10 percent
July	86.50 percent	36.98 percent
August	100.00 percent	69.68 percent
September	99.69 percent	59.28 percent
October	100.00 percent	74.73 percent
November	99.54 percent	90.64 percent
December	99.58 percent	91.57 percent

May, June, and July are free trial periods.

(2) Front-end computer mainframe (Convex C3840)

IBM ES9000 CPU User Status

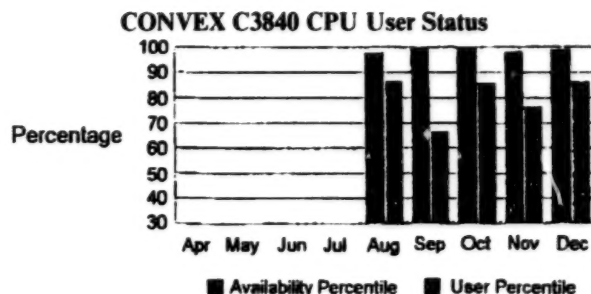


It has four central processing units (CPU), containing vector processing elements, a main memory unit 512MB, and magnetic disk 60GB.

Monthly operational status of front-end mainframe from April is as follows:

Month	Availability Rate	Using Rate
April	Installed	Installed
May	0 percent	0 percent
June	0 percent	0 percent
July	0 percent	0 percent
August	97.85 percent	86.63 percent
September	99.72 percent	66.55 percent
October	100.00 percent	85.74 percent
November	98.06 percent	76.39 percent
December	99.19 percent	86.25 percent

May, June, and July are free trial periods.



(3) There are about 30 sets of various types of plots and computing work stations.

(4) There are 150 sets of initial-step work stations.

Applied softwares:

- (1) Computationally applied mechanics
- (2) Computational mathematics
- (3) Scientific visual calculations
- (4) Physics, chemistry, biology
- (5) Electronic design
- (6) Distributed calculations

Application areas of high speed computations:

- (1) Computational chemistry and molecular modelling
- (2) Computational mechanics
- (3) Electronic design modelling
- (4) Computer efficiency evaluation
- (5) Civil Engineering
- (6) Atmospheric Sciences
- (7) Scientific visual calculations

3. Primary mission

Under aegis of the Government and National Science Council's mandated general S&T development goals, preparations for construction of the state high speed computer center were made in February 1993, and it was listed as an open state level public facility for S&T development, and it will serve as a center for assembling first-class foreign and domestic talent in applied high speed computer S&T, and as a base for international exchange and cooperation.

Its substantive missions are as follows:

- (1) Provide speed computer hardware and software systems, and create a forward-looking scientific and engineering computational environment.
- (2) To develop the high speed scientific and engineering computational methodologies and their applied software systems that advanced countries possess and Taiwan lacks.
- (3) To assist the industrial sector to make full use of high speed computational tools, and promote key technologies and spare parts and leading product R&D.

(4) Support the fostering of high-level talent in high speed computational applications in science and engineering arena.

To reach those goals, the high speed computer center, besides needing to invite computer specialists, needs to attract talent from many applicational specialties to interface between the center and the outside world to secure a better understanding of the software needs of customers, and to attain a common development of higher level research projects. The present specialists invited are in these specialty fields: mathematics (numerical analysis), aeronautics, machinery, electronics, chemistry, physics, structures, and the environmental protection, other domestic fields will be receiving further attention as needed and suitable talent (such as weather) will be invited.

4. Current Stage Vital Activity

(1) Propagation and fostering of experts in high speed computational applications

(1) Workshops and the Achievement Publicity Conferences

To promote academic exchange, the center often sponsors workshops and the achievement publicity conferences and invites the participation of academic and industrial sectors. It is the expectation of the workshops and the conferences that their research achievements will attract the attention and feedback of concerned academic departments and industries. Taiwan, Ch'engkung, Chungshing, and Chungshan Universities have been called upon to assist in the high speed computer training curricula, and have trained talent in that field.

(2) Establishment of a specialty-field study, discussion and utilization group

In addition to the center's high speed computer workshops, and the achievement publicity conferences, a specialty-fields study, discussion and utilization group was established to speed up the process of intellectual interchange, which, it is expected, will exchange relevant high speed computational research and experiences with participating user in their shared fields of interest, collect user suggestions and encourage meaningful user interchange, provide relevant information and applicable consultation services, and broaden high speed computational applications to promote interdisciplinary research. The specialty-fields study, discussion and utilization group has five component elements for computational chemistry, computational mechanics, numerical methodology and parallel computations, computational physics, and electronic design.

(3) Academic briefings and presentations of papers.

Presenting briefings to research units and the industrial sector is one of the most effective means of disseminating high speed computation. Research personnel from the center often speak to universities and research units to promote computational science in its various fields. Treatises are also presented at international conferences and published in specific journals.

(4) Deployment of software support personnel

In order to help the academic world gain access to relevant existing computer resources at various institutions and make good use of the center's facilities, five specialists from the center are stationed at Taiwan, Chungshing, Chungcheng, Ch'engkung, and Chungshan Universities to facilitate access to services and assistance.

(II) Establishment of a public program library

Public user programs have been purchased from abroad including, a physics software program library, and a mathematics software program library, as well as a protein data bank, which provides domestic academic and industrial sectors with high-quality, legal and free software programs. Among these is the public mathematic programs library, Netlib, developed and assembled by U.S. national laboratories, which is the best known and widely used public program library, and many local researchers frequently use the Taiwan Academic Network (TANet) to get needed programs from abroad. The State High Speed Computer Center is actively working with the U.S. Oak Ridge National Laboratory to get the Center established as one of Netlib's software dissemination centers, and the installations and testing for Netlib have already been done at the High Speed Computer Center and they are now formally opened up for use to outside users.

(III) Cooperation with industries

The Center will provide special technical consultation services and cooperation to the businesses to give specialized assistance and impetus to enterprise R&D programs, to raise the R&D capability and technology of domestic manufacturers and business firms, and strengthen the international competitiveness of Taiwan's products.

1. Very large-scale integrated circuits (VLSI)

In order to raise Taiwan's VLSI design capability, the Center has cooperated with the American business Corporation (Mingdao Corporation, Ltd.) in supplying high-performance hardware and software, in order to speed up the testing of advanced and developed products from its R&D efforts. It is hoped that the technology will then be transferred to the industrial sector, and that it will enhance the Center's capability to provide consultation and assistance in VLSI technology.

2. Simulated automobile collisions

The Center has worked with the Yulung Automobile Corporation on Taiwan's first "computerized all-vehicle collision simulation" research program. Its primary purpose is to use computers to simulate collisions to take the place of time-consuming and expensive vehicle collision testing and reduce the costs involved in the automobile design process. This computer-simulated all-vehicle collision program, developed on Taiwan, will be completed this June. This program, when completed, will be the

foundation stone for the Taiwan automobile industry's entry into computerized modelling and design analysis technology for all vehicles and accessories.

5. Outlook for the Future

Now the State High Speed Computer Center's first task is to function effectively as a high level consultative service provider to effectively use its facilities, and to develop "home-grown" software that meets local needs. The computer market is rapidly changing, new products push out the old, now the well-received parallel computational hardware and software will be the High Speed Computer Center's key task to evaluate. An early acquisition of large amount of parallel computers, work station group computers and distributed computation software is the new trends of future development of high speed computations. The Center hopes to build on this and establish a balanced and complete computational environment that is best for Taiwan's scientific and technological development.

6. Conclusions

The establishment of the State High Speed Computer Center still has to work to reach its star. With proper advertising the Center can provide computational services to the various academic and industrial sectors and mold a common effort to make Taiwan's S&T development whole and complete.

Taiwan State Seismic Engineering Research Center

946B0172B Taipei K'OHSUEH FACHAN YUEK'AN
[NATIONAL SCIENCE COUNCIL MONTHLY]
in Chinese Vol 22 No 6, Jun 94 pp 620-622

[Article by Ch'en Huitz'u [7115 1979 1964], Seismic Engineering Research Center]

[FBIS Translated Text]

1. Preface

Taiwan is located on the circum-Pacific seismic zone, and has a high incidence of earthquakes. The recent economic boom on Taiwan and the attendant increase in number of major engineering structures and buildings is such that, were they to be damaged by earthquakes, the loss of lives and property, and the impact on the economy and society would be inestimable. In October 1989, the Executive Yuan, having examined the matter, drew up a plan to build a "State Seismic Engineering Research Center," which became official in March 1990, and the National Science Council, acting on its authority, formally enlisted National Taiwan University to manage it, and for the present, the Center is set up at the Applied Mechanics Institute of Taiwan University.

2. Objectives

The State Seismic Engineering Research Center will bring domestic scholars, specialists and engineers involved in seismic engineering together, to engage in basic and applied research that is relevant to seismic engineering in both the theoretical and testing aspects of solving the problems of earthquake-proof problem on Taiwan, and to quickly raise

the level of quake-proof design, reduce earthquake damage, and guarantee the success of economic construction. The Center will also cooperate in the training of high-level expertise in earthquake engineering, concentrate research manpower, make research all encompassing, and conduct on-going academic exchange internationally to elevate Taiwan's academic standing of earthquake engineering research.

3. Present focus of effort

The present stage of activity comes down to four items: Constructing the research building and a large-scale laboratory, setting up seismic engineering terrain testing work stations, disseminating seismic engineering information and achievements, and planning and promoting seismic engineering research.

(1) Construction of research building and large-scale laboratory

The research building and large-scale laboratory for the Center will be located on the campus of National University of Taiwan on Hsinhai Road. The first stage of construction started in August 1993, and is expected to take two and one-half years. The research building will have six stories above ground and one below, and will have one briefing room, two classrooms, a library, conference room, display room, and research lab. The large-scale laboratory will have a seismic simulation facility, a small modelling lab, a large structure testing facility, a computer room and a testing control room. The seismic simulator is a five by five meter triple-axe vibrator with accessories to be used for shock testing structural models. The large-structure test facility will have L-shaped graduated reaction walls measuring variously: 15 meters, 12 meters, nine meters, and six meters on a strong base 29 by 60 meters in area, and the reaction wall and base can be used for static structural testing or event simulation testing. The small modelling lab will be used for materials testing and structural support testing. The testing control room's main function will be to monitor and control testing operations and collect testing materials. The relevant materials analysis and manipulations will be done in the computer room. Procurement and construction activities for the seismic stations are proceeding apace.

(2) Preparing seismic engineering terrain testing work stations

A seismic engineering terrain testing work station is being set up at the Ilan National Agriculture and Engineering Professional School in Ilan, one of the few such on-site research facilities in the world, whose chief purpose is to work with the Center in promoting large-scale research projects, and large-scale or full-scale models will be built on base there, in which a strong shock measuring system will be installed to measure the shock resistance of structures, and the models will be examined and analyzed to gain an understanding of the capability of structures to withstand and endure shocks. Besides the extraneous engineering and studying the activity of the strata which

have already been done at the work station, six tri-axial strong-quake seismic detectors are installed at the base and placed on the surface, and at location 15, 30, and 40 meters down in the earth, and there is one observation and measuring room with the pertinent measuring systems in it that record the incoming signals from the seismographic instruments. This year, two five-storied steel structures will be built there to accommodate the Sino-American "shock-wall and buffer elements installed in the steel structures for seismic reaction and analysis" research operations.

(3) Disseminating seismic engineering information and research results

From the time of its inception, besides buying seismic engineering periodicals, charts, books, treatises and research reports to give out as reference materials, the Center also acquired seismic engineering instructional materials and slides and video recordings of seismic disasters to give free of charge to schools, the general populous, and public and private organizations to spread the word about seismic engineering. Every three months a quarterly correspondence and scheduled or non-scheduled convocations and seminars are held for the purpose of disseminating seismic engineering information and research results. The Center has held such meetings as event testing and research study sessions, quake-resistant bridge span analysis and design seminars, structural bulwark earthquake-buffer technology seminars and highway bridge span earthquake-proofing design-programming seminars. The need to invite foreign research organizations to join in common seminars will be taken up in the future to stimulate more exchange in seismic engineering research among various countries, and briefings will be given to various levels of educational institutions to expand education in seismic engineering.

(4) Planning and promoting seismic engineering research

The Center is responsible for the consistency, programming, and promoting of seismic engineering research. Many research planning conferences have been held since the Center was established, calling together domestic scholars and specialists to discuss problems that urgently need to be solved and the 10 major near- and mid-term research plans involving the Centers' facilities and programs, including six research projects concerning buffering structures of buildings against earthquakes, two earthquake resistant bridge span projects, and two large earth engineering research projects. Because the large-scale research laboratory is still under construction, the vibrator and the event simulator can't be used for a while, and for the first three years, the facilities at the Ilan seismic engineering testing station will bear the load of large-scale research plans, with the participation of the Center's researchers and professors of major universities. Three plans are active now, of which the "Plan for installation of seismic detecting instruments in the newly built school building of the Ilan Agriculture and Engineering Professional School" has been underway for two years

now, and various types of monitoring and measuring instruments are installed in that school's newly built edifice (seven stories above ground and one below) where seismic recordings are measured to gain an understanding of the effects of earthquakes on structures and to check the accuracy of analytic models. There is also the "Testing and analysis of the earthquake resistance of shock-walls and buffering elements in steel structures" which has been going on for more than a year now, where the Center will be taking a look at the future potential of the anti-earthquake technology employed in shock-wall elements and other types of buffers that in the U.S., Japan, New Zealand are being developed rapidly and are coming into use, namely by means of the VE and ADAS dampers installed in the five-storied steel structure at the terrain testing work station, which eventually will be replaced by LRB shock-wall elements, adjustable dampers, and adjustable wall-sliding elements, to study and discuss the effectiveness of shock-walls and buffers on the reaction of the structure during shocks to establish a basis for their dissemination, and this plan includes cooperation with U.S. National Seismic Engineering Research Center at the NYU Buffalo campus in research using scaled-down vibrator tests. Third is the "Research on the problems of design in the seismic condition and soil liquefaction in Taiwan's soft basin," which is set to begin in August 1994, chiefly because:

- 1) Research on earthquake design in the past has largely concerned hard basins, and in soft-basin conditions, revisions with respect to the strata have to be made before suitable designs can be made, and a domestic program for earthquake design on a soft

basin have yet to be fully defined. But, many places in the western corridor of Taiwan where new cities and industrial zones are opening up, construction and engineering are in dire need of anti-earthquake design standards. The Center has, therefore, put together a mid-term research program with the intent to provide basic earthquake design materials for the Taiwan soft basin for local engineering design use.

- 2) Earthquakes are major natural disasters, and if before they occur feasible countermeasures can be put into effect that will be all to the good. It is evident from the majority of earthquake disasters that there can be a great variation in the extent of damage within the space of several tens to several hundreds of meters. The concept of predicting small scale variations in force and damage of earthquakes is called seismic microzonation. Once a sub-regional fluidity chart is produced, it will help to forecast the areas of damage fluctuations, and with that disaster relief can be vastly improved.

4. Prospects

There have been marked improvements in earthquake engineering and its applications on Taiwan, but simulated earthquake testing facilities are lacking, so the State Seismic Engineering Research Center will work, body and soul, to build a national level seismic engineering laboratory as early as possible, to carry out the large-scale research projects programmed for the Center's vibrator and large-scale structure testing facilities, and to raise the level of seismic engineering research and anti-earthquake design to guarantee the safety of life and property on Taiwan.

Heteroepitaxial Growth of Diamond Films on C-BN Substrate

946B0144A Beijing GAO JISHU TONGXUN [HIGH TECHNOLOGY LETTERS] in Chinese
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[Article by Jin Zengsun [6855 2582 1327], Lu Xianyi [0712 2009 5030], Zou Guangtian [6760 1639 3944] of State Key Laboratory for Superhard Materials, Jilin University, Changchun 130023: "Study of Heteroepitaxial Growth of Diamond Films on C-BN Substrate," funded by 863 Program; MS received 21 Dec 93]

[FBIS Translated Text] Abstract: Diamond films are grown on single-crystal C-BN substrate by the hot-filament CVD method, and the heteroepitaxial growth of diamond on the C-BN (100) facets is observed.

I. Introduction

Diamond has a bright application future in the field of electronics because of its superior electronic properties. The key to the realization of applying diamond films in the electronics field is the technology of diamond heteroepitaxial growth and vapor doping. Research on vapor doping of CVD diamond film is now rapidly progressing. P-type semiconductor diamond polycrystalline films that are essentially suitable for certain devices¹ have been produced and n-type semiconductor diamond polycrystalline films² with electric-conducting characteristics have also been produced. In recent years, epitaxial growth of diamond has been taken seriously: Homoepitaxial growth of diamond on high-pressure diamond or on natural diamond substrate facet with (100) crystal plane [i.e. (100) facet] has been achieved.³ Heteroepitaxial growth phenomena have been observed on a C-BN substrate⁴ as well as on a Ni substrate.⁵ This study investigates the heteroepitaxial growth of diamond on a C-BN substrate by the hot-filament CVD method.

II. Experimental Method

This study used CH₄ and H₂ gases as raw materials and adopts the hot-filament CVD process⁶ to prepare diamond films on the (100) or (111) facets of C-BN single-crystal substrates. The preparation parameters for diamond films are as follows: raw materials are CH₄ and H₂ gases; CH₄ concentration, 0.2 percent to 1.0 percent (mass ratio); basal plate temperature, 800°C to 950°C; and operating pressure, 1.32×10^3 Pa. The base plate is C-BN single crystal synthesized under high pressure and high temperature in the State Key Laboratory for Superhard Materials, Jilin University. The substrate surface is first cleaned with HF solution, alcohol, and distilled water, then with hydrogen plasma in vacuum.

This investigation analyzes the structure and growth characteristics of the depositions by Raman spectroscopy and the SEM method.

III. Experimental Results and Brief Discussions

Figure 1 shows the Raman spectra of the depositions. It shows a sharp diamond Raman characteristic peak at 1332 cm⁻¹ in addition to the Raman characteristic peak of the

C-BN substrate. Therefore, the depositions on the (100) and (111) facets of the C-BN crystal are cubic-structure diamond.

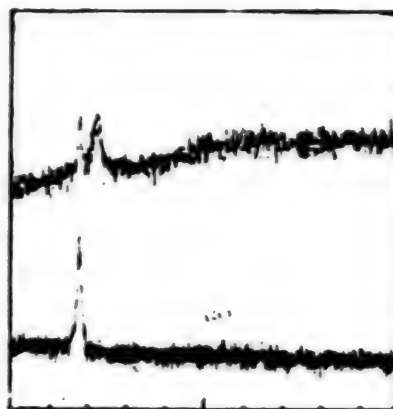


Figure 1. Raman Spectra of Precipitations on C-BN Substrate. (a) Spectrum of C-BN. (b) Spectrum of Precipitations.

SEM observation shows that on the rough C-BN (100) facet surface or on the surface with obvious defects, only diamond polycrystalline film is produced. However, the diamond film grows heteroepitaxially on the smooth and practically defect-free (100) facet of the C-BN crystal (Figure 2). Under the same parameters of this investigation, only diamond polycrystalline film grows on the (111) facet regardless of the surface condition (Figure 3).

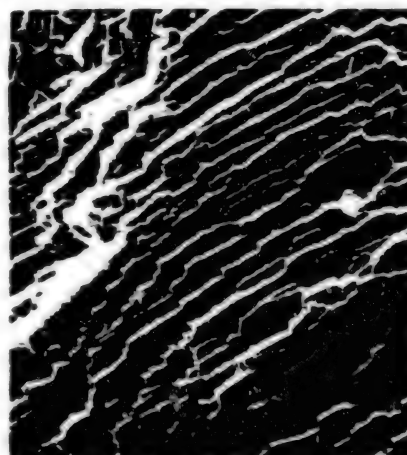


Figure 2. SEM Photo of Diamond Growth on C-BN (100)

We have studied the homoepitaxial growth of diamond,⁷ and found that it is easier for the film to grow epitaxially on the diamond (100) facet than on the diamond (111) facet. The diamond heteroepitaxial characteristics on the C-BN substrate are similar to the diamond homoepitaxial characteristics. Both growths are closely affected by the crystal surface structure of the substrate.



Figure 3. SEM Photo of Diamond Growth on C-BN (111)

This study investigates the diamond heteroepitaxial growth as related to methane concentration and substrate temperature. Under the conditions of this study, when the methane concentration is greater than 0.5 percent and the substrate temperature is below 900°C, only diamond polycrystalline film is formed on the C-BN (100) facet, and no heteroepitaxial growth is observed. This observation coincides with the results of experiments on the heteroepitaxial growth of other thin-film materials. Figure 4 shows the SEM photo of the diamond growth on the C-BN (100) facet when the substrate temperature is 800°C. We realize that high substrate temperature and low growth rate facilitate the heteroepitaxial growth.⁸ Most of the thin-film materials have their specific minimum substrate temperatures required for heteroepitaxial growth. The minimum temperature is affected by the substrate material and its topography. The growth rate of the diamond film depends on the methane concentration. The lower the methane concentration is, the smaller the growth rate becomes. Therefore low methane concentration favors the diamond heteroepitaxial growth.

IV. Brief Conclusions

The structure of C-BN crystal is like that of diamond. The C-BN lattice constant is close to that of diamond. As there is low lattice mismatch between C-BN and diamond crystals, C-BN single crystal is the optimum substrate for diamond heteroepitaxial growth. In the experiment, diamond heteroepitaxial growth is observed on a smooth and practically defect-free C-BN (100) facet, while only the growth of diamond polycrystalline film is observed on the

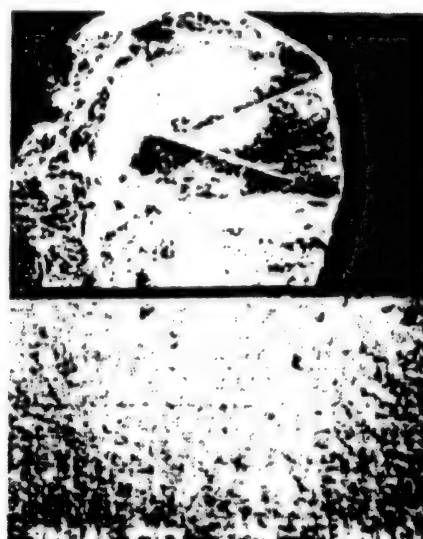


Figure 4. SEM Photo of Diamond Film on C-BN (100); Substrate Temperature, 800°C

C-BN (111) facet. These observations indicate that diamond heteroepitaxial growth is related to the crystal surface structure of the substrate. High substrate temperature and low methane concentration favor diamond heteroepitaxial growth. Under our experimental conditions, when the substrate temperature is above 900°C and the methane concentration is below 0.5 percent, diamond heteroepitaxial growth is observed on the C-BN (100) facet.

References

1. Fujimori, N., Imai, T., and Dio, A., VACUUM, 1986, 36: 99.
2. Okano, K., Kiyota, H., Iwasaki, T., et al., APPL. PHYS., 1990, A51: 344.
3. Sato, Y., STA, National Institute for Research on Inorganic Materials, Research Report #69, 1991, p 10 [in Japanese].
4. Koizumi, S., Murakami, T., Inuzuka, T., and Suzuki, K., APPL. PHYS. LETT., 1990, 57: 563.
5. Sato, Y., STA, National Institute for Research on Inorganic Materials, Research Report #69, 1991, p 12 [in Japanese].
6. Jin Zengsun, Lu Xianyi, Qu Chenglin, et al., JILIN DAXUE ZIRAN KEXUE XUEBAO [JOURNAL OF JILIN UNIVERSITY, NATURAL SCIENCES EDITION], 1987, 2:127 [in Chinese].
7. Jin Zengsun, Lu Xianyi, Huangpu Ping, et al., REN-GONG JINGTI XUEBAO [JOURNAL OF ARTIFICIAL CRYSTAL], 1990, 2:133 [in Chinese].
8. Sloope, B.W., Tiller, C.D., J. APPL. PHYS., 1965, 36: 3174.

SiCw/SiC Ceramic Composites Fabricated by Chemical Transformation from Polycarbosilane

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[Article by Feng Chunxiang [7458 2504 4382], Huang Kaibing [7806 0418 0365], Zhang Changrui [1728 7022 3843], and Chen Zhaohui [7115 2600 6540] of Department of Materials Science and Applied Chemistry, National University of Defense Technology, Changsha, 410073: "Study of SiC Whisker-Reinforced SiC Ceramic Composites Fabricated by Chemical Transformation from Polycarbosilane," funded by 863 Program; MS received 3 Jan 94, revised 8 Feb 94]

[FBIS Translated Text] Abstract: The forming technique and thermal properties of SiCw/SiC ceramic composites using SiCw whisker as reinforcement and polycarbosilane as precursor are investigated. The high-temperature oxidation mechanism of SiCw/SiC ceramic composites is studied. The density and bending strength of the prepared SiCw/SiC composite are 2.19 gram per cubic centimeter (g/cm^3) and 250 MPa, respectively.

I. Introduction

SiC ceramic composite material is superior because of its good high temperature strength, thermal shock resistance, low density, high hardness, good fretting resistance, low coefficient of thermal expansion, and good heat conductivity. SiC ceramic composite with continuous fibers or whiskers as reinforcement has become a new member of the family of composite materials. It is an ideal high-temperature structural ceramic.

The hot-press sintering method is difficult to use for mass-producing parts with complicated shapes, and it damages the mechanical properties of the reinforcing fibers; therefore, it is difficult to utilize the reinforcing effect of the fibers.¹ For years, many materials scientists have dedicated themselves to research on preparing fiber-reinforced SiC composites under conventional pressures and relatively low temperatures in order to improve the mechanical strength and fracture ductility of the SiC material. This study, using polycarbosilane as precursor for the SiC matrix and SiC whisker as the reinforcing material, investigates SiCw/SiC composite prepared under conventional pressure and comparatively low temperature. The advantages of this preparation method are: the prevention or reduction of fiber damage by low-temperature sintering, the reduction of impurities as no sintering activity agent is needed, and the feasibility of making complicated parts and multi-element ceramic composites. The method opens the way toward making SiC composites under conventional pressure and low temperature.

II. Experimental Work

1. Raw Materials

- (1) SiC crystalline whiskers are made by the Tokai Carbon Co., Japan, with specifications as follows: diameter, 0.1 μm - 1.0 μm ; length, 30 μm - 100 μm ; density, 3.19

g/cm^3 ; length/diameter ratio, 50 - 200; apparent density, 0.1 g/cm^3 ; heat-resisting temperature (inert atmosphere), 1600°C; and SiC particle content < 1 weight-percent.

- (2) Polycarbosilane (PC) is a polymer from thermally decomposed polydimethyl silane and rearranged with SiC as the main chain, $M_n = 1000$. Its softening temperature is between 96°C and 116°C.

2. Forming Technique

SiCw or SiCp, PC/Toluene \rightarrow Dispersion Treatment \rightarrow Solvent Removal \rightarrow Grinding, Screening \rightarrow Mold Pressing into Blank \rightarrow Sintering \rightarrow Repeated Infiltration and Heat Treatment \rightarrow SiCw/SiC, SiCw, SiCp/SiC Materials, SiCp/SiC

3. Analyses and Tests

(1) Three-Point Bending Test:

The specimens are cut with a diamond slicing machine to the specified dimensions of 3mm x 4mm x 35mm, and then tested with an L-1000B electron tension testing machine (span, 30mm; test loading speed, 2mm/min). Each presented datum is the averaged test value for the three specimens.

(2) Thermal Shock Test:

The specimen is heated in a muffle furnace to 1000°C, then quickly quenched in 100°C boiling water, after which it is taken out from water and dried by baking, then quenched in 100°C boiling water again. This process is repeated over and over. After a certain number of cycles, the specimen is tested for its three-point bending strength.

(3) Oxidation Resistance Test:

After the specimen is oxidized in a muffle furnace at 1250°C for a certain period of time, its weight is precisely measured, its weight increase rate is calculated, and its three-point bending strength after oxidation is tested.

III. Results and Discussion

1. Influence of Forming Technique on Composite Bending Strength

A crucial problem in the preparation of the SiC whisker-reinforced ceramic composite is how to uniformly disperse the whisker in the matrix. Uneven dispersion causes greater interior defects of the composite, which weakens the material strength. The frequently used dispersion method is to disperse the whiskers in water or in organic solvents (toluene, xylene, or n-hexane) by supersonic vibration, or to add certain organic suspending agents in solvent for dispersion by supersonic vibration. This experiment uses a mixture of PC and xylene as solvent. The supersonic vibration of the whiskers achieves the dispersion effect. Table 1 and Figures 1 and 2 show the material properties as influenced by the forming pressure, ratio of SiCw to PC, and the number of repetitions of liquid-phase PC infiltrations.

Table 1. Effect of Forming Technique on Strength of SiCw/SiC Composite

Specimen Number	S-IA	S-IIA	S-IIIA	S-IVA
PC content (wt%)	12	15	17	20
Forming pressure (MPa)	306	153	306	153
Blank density (g/cm ³)	1.29	1.24	1.45	1.10
Expansion after sintering (%)	2.64	6.06	4.67	9.09
Sintering density (g/cm ³)	1.15	0.98	1.19	0.80
Relative PC loss (%)	38.3	39.1	37.6	39.4
Density after six infiltrations (g/cm ³)	2.14	2.07	2.10	1.82
Bending strength (MPa)	203.6	194.6	249.5	132.9
Specific strength (σ/d) cm	95.14	94.09	118.9	73.02
SiC whisker content (wt%)	49.0	45.4	54.5	42.2

All specimens are sintered at 1380°C in N₂ atmosphere for 2 hours.

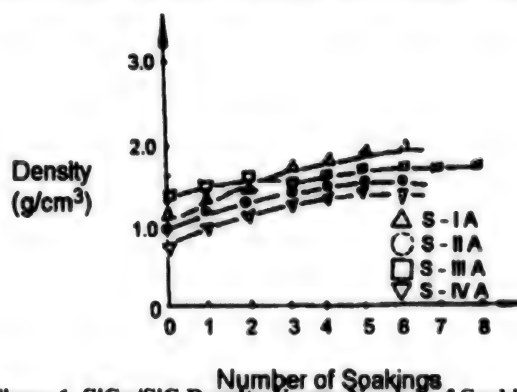


Figure 1. SiCw/SiC Density Versus Number of Soakings

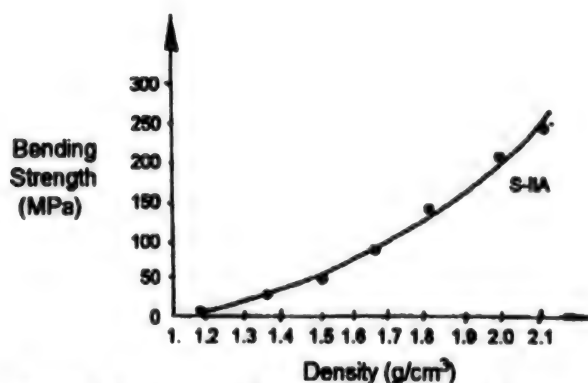


Figure 2. Relationship Between SiCw/SiC and Bending Strength

Table 1 shows:

- (1) The forming pressure greatly affects the blank density, the expansion rate of the sintered blank, and the sintered density. Generally speaking, the best forming pressure is 300 MPa.
- (2) Blisters and laminations are apt to occur when the PC content is 20 weight-percent. The composite strength is higher when the PC content is 12 to 17 weight-percent.
- (3) The composite density gradually increases with the increase of PC infiltration repetitions. Since the surface pores become smaller with each infiltration, the PC molecule diffusion into the material becomes more difficult. As a result, the composite densification rate slows down during later infiltrations.
- (4) The bending strength of SiCw/SiC composites increases nonlinearly, in an accelerated manner with the increase of density. Since the density increase is restricted, the rate at which material strength increases is also restricted. This drawback can be improved by other means.

During the process of thermal decomposition of PC into B-SiC microcrystals, the organic polymer transforms to amorphous SiC. The B-SiC resulting from the transformation of PC wraps around the whisker surfaces and forms a continuous matrix phase. This continuous phase structure forms a complete network with the non-sintered whiskers, and thereby increases the composite strength. We can easily see that higher forming pressure tends to densify the blank more, and further reduces the voids between the whiskers. This facilitates the transformation of PC to the SiC matrix, which bonds the whiskers together to form a solid network structure that strengthens the material. As the number of infiltrations increases, the continuous phase builds up. Eventually, a complete network structure gradually forms, and the composite strength as well as the composite specific strength are progressively enhanced.

2. SiCw/SiC Composite Thermal Physical Characteristics

(1) Thermal Shock Resistance

At present, the shock-resistance measurements of ceramic materials are still mainly simulations based on application conditions. We use a comparison method with the SiCp/SiC composite (density, 2.13 g/cm³) as reference. As shown in Figure 3, the bending strength of the SiCw/SiC composite greatly decreases after repeated thermal shock cycle treatments. Yet, the bending strength of the SiCp/SiC composite made by the same technique shows slight increases until the 8th cycle, and remains unchanged afterwards. The different bending strengths are caused by high-temperature oxidation. Thermal shock cycle tests in this study are conducted under a hot and humid oxidation environment; hence the prerequisite of maintaining good thermal shock resistance is the material's superior oxidation resistance. The drop of SiCw/SiC composite

bending strength is possibly caused by high-temperature oxidation. Therefore, the exploration of and solution to the problems of SiCw/SiC high-temperature oxidation and strength reduction are highly important.

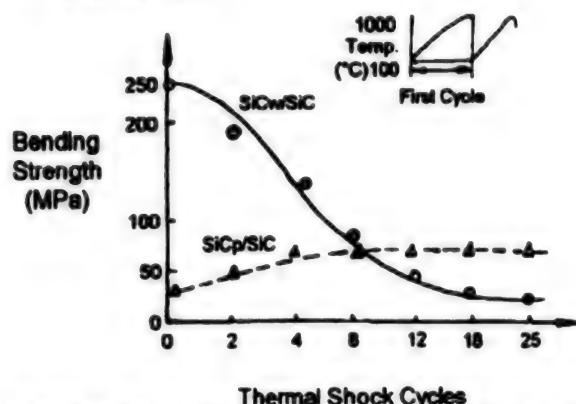


Figure 3. Relationship Between Bending Strength and Thermal Shock Cycles for SiCw/SiC and SiCp/SiC

(2) High-Temperature Oxidation Resistance Properties

Oxidation tests at 1250°C in air on the SiCw/SiC and SiCp/SiC composites prepared by the same technique have been conducted. As shown in Figure 4, the oxidation weight gain of SiCp/SiC is smaller than that of SiCw/SiC. Under the same test conditions, SiCp/SiC with a density of 2.8 g/cm³ shows almost no weight gain, which indicates that the SiCp/SiC composite has formed a certain protecting layer that prevents the progress of oxidation; while the oxidation weight gain of SiCw/SiC increases parabolically with time, which indicates that oxidation continues throughout the test.

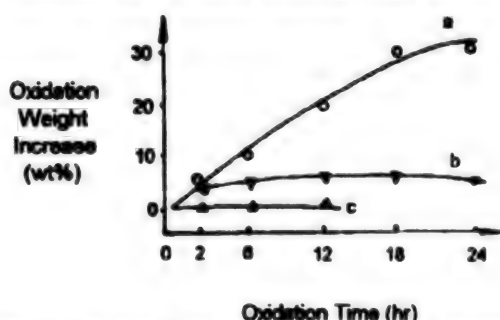


Figure 4. Relationship Between Oxidation (1250°C) Weight Increase and Oxidation Time for SiCp/SiC and SiCw/SiC. a. SiCw/SiC $d = 2.10$ g/cm³; b. SiCp/SiC $d = 2.13$ g/cm³; c. SiCp/SiC $d = 2.68$ g/cm³

Furthermore, the obvious bending strength difference of the two composites after oxidation (Figure 5) indicates that the oxidized layer of SiCw/SiC does not effectively provide protection. The bending strength of SiCw/SiC

decreases parabolically with the oxidation duration. After 24 hours of oxidation, the bending strength of SiCw/SiC composite drops to 35 MPa as compared with 249.5 MPa for the unoxidized specimen.

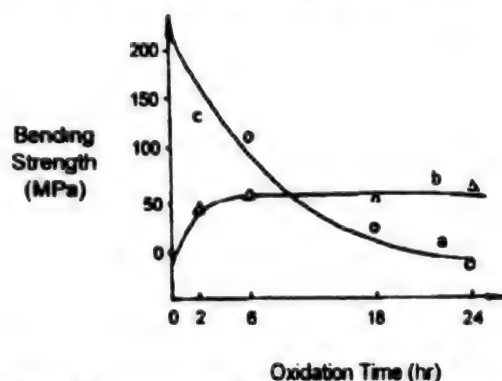


Figure 5. Relationship Between Bending Strength and Oxidation Time for SiCw/SiC and SiCp/SiC. a. SiCw/SiC; b. SiCp/SiC

3. Exploratory Study of SiCw/SiC Composite's High-Temperature Oxidation Mechanism

In an oxidation environment, SiC is a thermodynamically unstable system where the reaction of $\text{SiC} + 2\text{O}_2 \rightarrow \text{SiO}_2 + \text{CO}_2$ exists. Thermodynamically, SiC is oxidized easily. When the surface oxidation layer reaches a certain thickness, it becomes a protection layer that prevents oxygen diffusion and further oxidation. Research on SiC oxidation dynamics by Erwin, et al.² shows that at below 900°C, the oxidation of SiC proceeds very slowly; and at above 1600°C, it proceeds so fast that the oxidation product evaporates. When the temperature is between 900°C and 1600°C, the oxidation is controlled by the diffusion condition, which depends mainly on the specific surface area of SiC particles or fibers and the oxygen partial pressure. The SiCp and SiCw phases before and after the 1250°C oxidation are analyzed. Both oxidation products are SiO₂; however, the oxidation product of β -SiCw is mainly amorphous (glass) SiO₂, while that of α -SiCp, mainly quartz.³

In addition to the crystal structure difference of SiC whiskers and particles, their surface areas are the major factors affecting the SiC oxidation rate (Table 2).

Table 2. Properties of β -SiC Whisker and α -SiC Particle after 6 Hours Oxidation at 1250°C in Air

Specimen	Average Diameter (μ m)	Oxidation Weight Increase (wt%)	SiC Oxidation Rate (%)	Oxidation Layer Thickness (μ m)	Half-Life τ (hr)
β -SiC whisker	0.55	43.88	87.8	0.48	1.26
α -SiC particles	4	20.74	41.48	0.66	9.53

Based on the Junder equation of diffusion control dynamics, smaller diameter results in larger diffusion reaction specific surface, shorter half-life, and worse oxidation resistance.

The morphology inside SiCw/SiC reveals that there are numerous pores which are connected. The connected-pore structure has larger diffusion reaction specific surface, which makes oxygen diffusion to the interior easier and causes serious oxidation. On the contrary, there are fewer pores in SiCp/SiC and most of the pores are closed or half-closed. This microstructure is formed due to the fact that the small diametrical dimension and large length/diameter ratio of the SiC whisker make it difficult for a dense conglomeration to form. Moreover, the two oxide products are different (quartz SiO₂ and glass SiO₂). The glass SiO₂ has a smaller thermal expansion coefficient than SiC, hence at high temperature, the glass oxides tend to enlarge the pores; while quartz SiO₂ has larger thermal expansion coefficient than SiC, hence at high temperature, quartz oxides tend to shrink the pores. Therefore, the glass SiO₂ produced through SiCw/SiC oxidation cannot effectively prevent the oxygen diffusion. Consequently, the oxidation process continues, resulting in inferior oxidation resistance of the SiCw/SiC composite.

IV. Conclusions

Research on the forming technique of SiCw/SiC composite prepared with PC as precursor for the SiC matrix shows that at high temperatures, PC transforms to the continuous phase of β -SiC microcrystals which connects the SiC whiskers to form a network structure, resulting in good composite strength. The prepared SiCw/SiC composite has a density of 2.10 g/cm³, and bending strength reaches 250 MPa at room temperature. The composite oxidation research shows that SiCw/SiC forms glass SiO₂ when oxidized at high temperature (1250°C). Since the glass SiO₂ cannot effectively prevent oxygen diffusion, the SiCw/SiC composite oxidation resistance is weakened.

References

1. Zhang Changrui, Chen Zhaohui, and Feng Chunxiang, YUHAN CAILIAO GONGYI [AEROSPACE MATERIALS TECHNOLOGY], 1989, 1:8 [in Chinese].
2. Erwin, G., et al., J. AM. CERAM. SOC., 1958, 41:347.
3. Chen Zhaohui, Report on Project 715-13-01-04, 1989 [in Chinese].

Carbon Fiber Reinforced C-SiC FGMs Prepared by CVI

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[Article by Liu Wenchuan [0491 2429 1557], Wang Zuoming [3769 0155 2494] et al. of the CAS Institute of Metals Research, Shenyang 110015: "Carbon Fiber Reinforced C-SiC Functionally Gradient Materials Prepared by CVI," supported by grant from NSFC; MS received 17 Jan 94, revised 4 May 94]

[FBIS Abstract] Carbon fiber reinforced C-SiC functionally gradient materials (FGMs) have been prepared by chemical vapor infusion (CVI). The thermal-gradient process used in this work involves either stepped deposition or codeposition from a C₂H₂ + CH₃SiCl₃ + H₂ + Ar system. The carbon fiber preform is a PAN-based carbon felt with a density of 0.1 gm/cc. Sample FGMs have the following dimensions (in mm): 150 x 8 x 250. The microstructure, distribution of Si in the matrix, mechanical and physical properties, and thermal barrier characteristics of the FGMs are investigated. FGMs produced by codeposition have the following parameters: density for inner and outer sides is 1.17 and 1.81, respectively; tensile strength for inner, middle, and outer sides is 28.01, 37.15, and 30.76 MPa, respectively; bend strength for inner and outer sides is 108.23 and 108.3 MPa, respectively; and oxide weight-loss rate for the inner and outer sides is 0.2417 and 0.1079 g/m²·S.

Six figures show photographs of the FGM samples and a graph of thermal expansion rate vs temperature for the codeposition samples. There are no tables. References: 5 English, 1 Japanese.

Latest Stealth/Counterstealth Research

Broadband Modified B-Sandwich Radome Structure

946B0157A Beijing DIANZI KEXUE XUEKAN
[JOURNAL OF ELECTRONICS] in Chinese
Vol 16 No 3, May 94 pp 232-237

[Article by Wang Duxiang [3769 4648 4382] of the Nanjing Electronic Equipment Institute, Nanjing 210016: "Broadband Modified B-Sandwich Radome Wall Structure"; MS received 9 Nov 92, finalized 18 May 93. (Wang Duxiang: male, born 1965, engineer with a Master's degree; currently engaged in research and development of receivers and electronic countermeasures; areas of interest include microwave technology, radome design and microwave CAD etc.)]

[FBIS Translated Excerpt] Abstract: In this paper, an effective broadband B-sandwich layer used for radome wall structure is introduced. This structure has a power transmission coefficient higher than 80% over incident angles from 0° to 70° and over a frequency band from 0 to 40 GHz. Also, the difference in insertion phase delay (IPD) between vertical polarization and horizontal polarization for this structure is very small.

1.0 Introduction

There exists a wide variety of radomes which have different design specifications to meet different requirements. With advances in technology, the number of radar designs in electronic warfare is constantly increasing, and the performance of radar systems continues to improve. In order to improve the anti-jamming capability of guidance systems and electronic equipment, many new technologies such as frequency hopping and multi-mode operation have been adopted. These technologies have imposed broadband and multi-mode requirements on the radome design; the development of the anti-radiation missile has also imposed direct requirements of broadband detection capability on the radome design.

In an effort to increase the radome's effective bandwidth, radome designers have proposed designs with different radome materials and wall structure; these include the single-layer structure,^[1] the metallic structure^[2] and the slot structure.^[3] While these designs have been used in actual broadband radomes, they have certain limitations because of the following problems: difficulty in selecting the proper materials, structural complexity, inadequate structural strength, and difficulty in fabrication.

In an effort to solve these problems, this paper presents an analysis of the transmission characteristics of a multi-layer dielectric plate, and proposes a modified B-sandwich-layer radome wall structure with good broadband electric properties over a wide range of incident angles. This design has relatively high structural strength, and can be used in many electronic applications including broadband radomes for high-speed missiles.

2.0 Design Theory

2.1 Design of Multi-Layer Dielectric Plate

The rigorous method of determining the electromagnetic (EM) field in the vicinity of an antenna-radome system is to treat the electric source of the antenna and the EM field of the radome and its surroundings as an entity, and to solve the boundary-value problem where the boundary conditions are defined by the antenna and the radome. However, the application of this method currently is limited to the solutions of a few extremely simple radome configurations. For this reason, approximate methods are often used to analyze radome performance. It has been shown^[4] that when the radius of curvature of the radome surface is greater than 1.5, the approximate method based on ray optics provides good analytical results. In this method, the energy of the EM wave is assumed to propagate along the direction of "rays," and the transmission of energy at the boundary of the dielectric surface behaves in the same manner as at a plane surface. Thus, the EM field at a near-field point corresponds to a series of waves transmitted by the antenna toward the radome. Let us consider a plane wave incident on an infinitely large dielectric plate, which represents the tangent plane at the intersection of the incident wave and the radome, as shown in Figure 1. In other words, the problem of an arbitrary EM wave incident on an arbitrary radome is approximated by the problem of a local plane wave incident on an infinitely large dielectric plate.

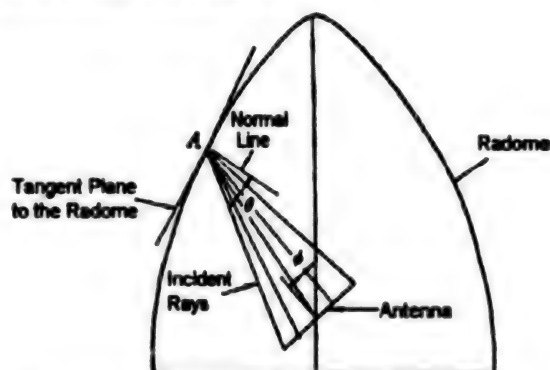


Figure 1. Schematic Diagram of the Antenna-Radome System

It can be seen from Figure 1 that for a fixed antenna turn angle ϕ , if the curvature of the radome at point A is increased, i.e., if the radome is more streamlined, then the incident angle of the ray at point A also increases. Therefore, a key to designing a highly streamlined broadband radome is to design a broadband dielectric plate over a wide range of incident angles.

2.2 Transmission Characteristics of a Multi-Layer Infinitely Large Dielectric Plate

The design of radome wall structure involves both electrical design and structural design; given that the structural requirements are satisfied, then the design objective is to optimize the electrical performance. The study of electrical performance of the radome wall structure can be reduced to a simple problem of studying the transmission characteristics of a plane wave incident on a multi-layer dielectric plate.

As shown in Figure 2, consider a homogeneous, isotropic N -layer infinitely large dielectric plate in free space. The dielectric constants ("permittivities") of the individual layers are $\epsilon_1, \epsilon_2, \dots, \epsilon_N$; the permeabilities are $\mu_1, \mu_2, \dots, \mu_N$; the dissipation tangents are $\text{tg}\delta_1, \text{tg}\delta_2, \dots, \text{tg}\delta_N$; and the corresponding thicknesses are d_1, d_2, \dots, d_N , respectively. The parameters ϵ_n, μ_n , and $\text{tg}\delta_n$ are all functions of frequency. When a plane wave enters the dielectric plate from free space at an angle θ , the wave is reflected and transmitted between each layer of the dielectric plate.

When a plane wave with an arbitrary polarization is incident on an N -layer infinitely large dielectric plate, the wave can be decomposed into two orthogonal linearly polarized waves. An oblique incident plane wave with an arbitrary polarization can be decomposed into a vertically polarized wave whose electric field is perpendicular to the incident plane and a horizontally polarized wave whose electric field is parallel to the incident plane. These two polarized waves have different transmission characteristics and different reflection characteristics.

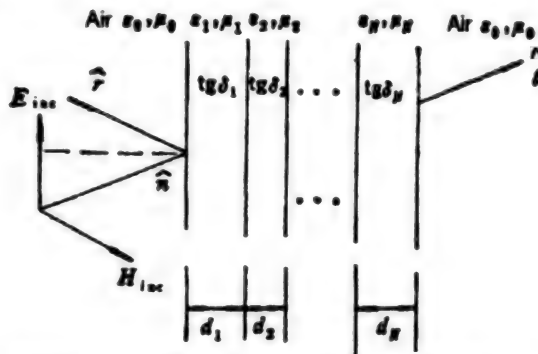


Figure 2. A Plane Wave Incident on a Multi-Layer Infinitely Large Dielectric Plate

[Passage omitted]

2.3 B-Sandwich Layer and Its Modified Structure

The B-sandwich layer structure of the radome is shown in Figure 3. In transmission theory, this structure is equivalent to a quarter-wavelength impedance converter with matched surface and core layers. This three-layer dielectric plate is symmetric with respect to the core layer, whose dielectric constant is larger than that of the surface layers. The unique feature of this structure is that the thickness of the core layer can be quite flexible, and its harmonic bandwidth can be used in the design of multi-band radome wall structures.

For a conventional B-sandwich layer structure, the thickness of the surface layer should be chosen based on the incident angle^[6]:

$$d_s = \lambda / (4\sqrt{k_{cs} - \sin^2\theta}), \quad (5)$$

where k_{cs} is the relative dielectric constant of the surface material, d_s is the thickness of the surface layer, and λ is the

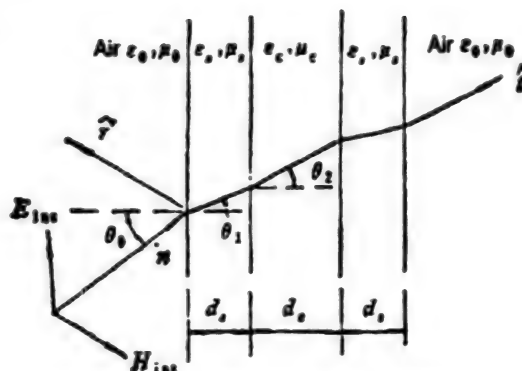


Figure 3. B-Sandwich Layer Structure

wavelength of the incident wave in free space. The relationship between the dielectric constants of the core material and the surface material is:

$$k_{cs} = k_{cc}^2, \quad (6)$$

where k_{cc} is the dielectric constant of the core material. In the case of vertical polarization, we have:

$$k_{cs} = \sqrt{k_{cc}} \cos \theta_0 \cos \theta_2 / \cos^2 \theta_1; \quad (7)$$

In the case of horizontal polarization, we have:

$$k_{cs} = \sqrt{k_{cc}} \cos^2 \theta_1 / (\cos \theta_0 \cos \theta_2). \quad (8)$$

In equations (7) and (8), θ_0 is the angle of incidence; θ_1 is the angle of refraction as the EM wave enters the surface layer; θ_2 is the angle of refraction as the wave enters the core layer.

Because of the low dielectric constant and inadequate strength of the surface layer, broadband application of the B-sandwich layer in practice is limited. In view of the presence of the dissipation tangents $\text{tg}\delta_s$ and $\text{tg}\delta_c$ in the surface layer and the core layer, and the fact that $\text{tg}\delta_s, \text{tg}\delta_c, k_{cs}$ and k_{cc} are all functions of frequency, equations (5)-(8) should be modified in the actual design application; specifically, k_{cc} and k_{cs} should be replaced by the complex dielectric constants $k_{cc} = k_{cc}(1 - j\text{tg}\delta_c)$ and $k_{cs} = k_{cs}(1 - j\text{tg}\delta_s)$. Through design optimization and use of the available new materials, a "modified" B-sandwich layer structure can be developed. This new structure has both good electrical performance and high structural strength.

3.0 Design Results

A conventional B-sandwich layer structure can satisfy the aerodynamic requirements of the radome on a high-speed missile if its surface layer is made of the non-carbonized abrasion material Duroid 5870, which has a relative dielectric constant of 2.5. Its structural strength is provided by a reinforced core layer which is made of fiberglass and has a relative dielectric constant of 6.25. Clearly, $k_{cc} = k_{cs}^2$. If the

relative permeability of each layer is 1, one can apply equations (5), (7) and (8) to obtain an optimum design of the B-sandwich layer structure. This structure has a power transmission coefficient of 60% within a range of incident

angles from 0° to 60° and over a frequency band from 0 to 40 GHz; its surface layer is 1.47 mm thick, and its core layer can have any thickness less than 3.9 mm. The results are shown in Table 1.

Table 1. Comparison of Several Sandwich Layer Structures

Type of Sandwich Layer	Core Layer			Surface Layer			Angle of Incidence $\theta(^{\circ})$	Frequency $f(\text{GHz})$	Power Transmission Coefficient T^2
	Relative Dielectric Constant k_{ec}	Thickness d_c (mm)	Dissipation Tangent $\text{tg}\delta_c$	Relative Dielectric Constant k_{es}	Thickness d_s (mm)	Dissipation Tangent $\text{tg}\delta_s$			
B-sandwich layer	6.25	≤ 3.9	—	2.5	1.47	—	0-60	0-40	$\geq 60\%$
Modified B-sandwich layer	6.56 \pm 0.02	≤ 7.5	≤ 0.005	2.5 \pm 0.02	1.47 \pm 0.1	≤ 0.005	0-70	0-40	$\geq 80\%$
Metal-reinforced A-sandwich layer	—	5.1	—	—	1.5	—	0	14-31	$\geq 80\%$

Within the frequency range 0-40 GHz, the relative dielectric constants of the Duroid material and the fiberglass vary no more than ± 0.02 , and the dielectric dissipation tangents of every layer are smaller than 0.005; thus, one can use $k_{es} = 2.5$ and $k_{ec} = 6.25$ as initial values and perform design optimization with respect to the objective function given in equation (3). The result is as follows: if the core layer's thickness is less than 7.5 mm and its relative dielectric constant is 6.56 \pm 0.02, and the surface layer's thickness is 1.47 \pm 0.1 mm and its relative dielectric constant is 2.5 \pm 0.02, then the power transmission coefficient is higher than 80% within the range of incident angles from 0° to 70°. The validity of this design approach and the design results have been verified by experimental results.^[7] Obviously this structure does not satisfy the condition $k_{ec} = k_{es}^2$. The properties of this modified B-sandwich layer structure are shown in Table 1 and Figures 4-7.

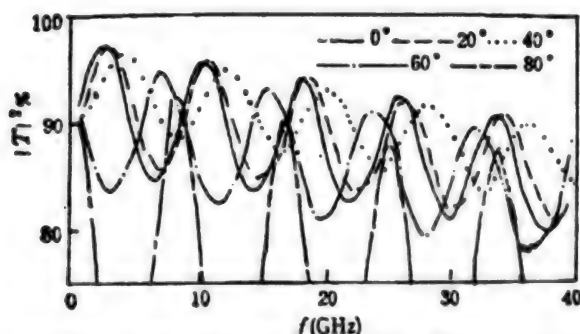


Figure 4. Vertically Polarized Power Transmission Coefficient of the Modified B-Sandwich Layer

For purposes of comparison, Table 1 also includes the performance of the wideband metal-reinforced A-sandwich layer.^[8] The results show that the modified B-sandwich layer is superior to the conventional B-sandwich layer in both electrical performance and structural strength; its power transmission coefficient increases with increasing core thickness and increasing range of incident angles. The advantages of the modified

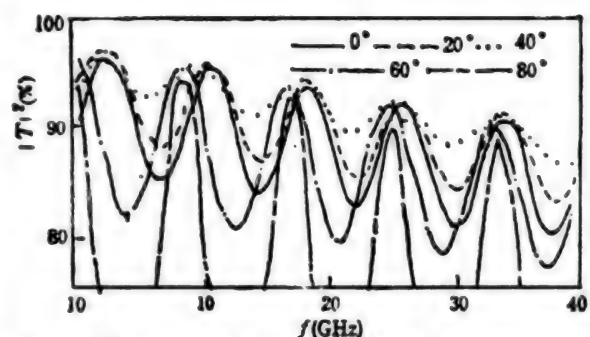


Figure 5. Horizontally Polarized Power Transmission Coefficient of the Modified B-Sandwich Layer

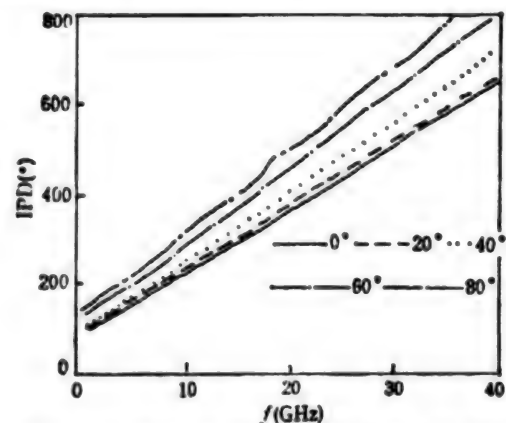


Figure 6. Vertically Polarized IPD of the Modified B-Sandwich Layer

B-sandwich layer are particularly pronounced when compared with the metal-reinforced A-sandwich layer. In the case of the A-sandwich layer, the optimum thickness for vertical polarization differs considerably from that for horizontal polarization at large angles of incidence; therefore, an optimum design for one polarization may be very poor for another polarization. Furthermore, at large

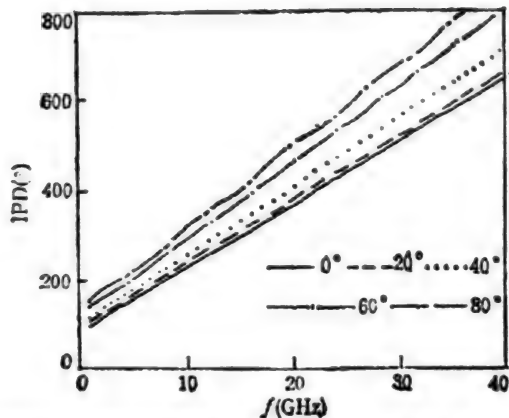


Figure 7. Horizontally Polarized IPD of the Modified B-Sandwich Layer

angles of incidence, the IPDs for the two polarizations also differ by a significant amount. For these reasons, the A-sandwich layer structure is not suited for highly streamlined radomes. It can be seen from Figure 6 and Figure 7 that for the modified B-sandwich layer, the difference in IPD between the two polarizations is extremely small.

4.0 Conclusions

The modified B-sandwich layer structure proposed in this paper is superior to the conventional B-sandwich layer structure in both electrical performance and structural strength. It provides a new technical approach for broadband radome design that overcomes many of the problems associated with the A-sandwich layer, e.g., large difference in electrical performance between horizontal and vertical polarizations, narrow bandwidth, and degradation in transmission characteristics at large angles of incidence. It is expected that this structure will be widely used on broadband radomes, particularly on highly streamlined radomes for high-speed missiles.

Acknowledgment: Thanks are due to Research Fellow Peng Wangze for his guidance and assistance in this work.

References:

1. Bassett, H.L., Bodnar, D.G., "Broadband Radome Techniques," AD-A085663. 1974.
2. Ernst, J.S., "Broadband Metallic Radome," AFAL-TR-79-1142. 1979.
3. Rope, E.L., Tricoles, G., "Broadband Millimeter-Wave Radome," Proceedings of the 15th Symposium on Electromagnetic Windows, Georgia, U.S.A.: 1980, 93-95.
4. Kaplan, B.A., "Ultra-High-Frequency Radomes" (Part I), Beijing: Eighth Ministry of Machine-Building Industry, Third Academy, Third Department, 1980, Section 2.8.

5. Cornbleet, S., "Microwave Optics—The Optics of Microwave Antenna Design," London, New York, San Francisco: Academic Press, 1976, 162-167.
6. Wang Duxiang, "Technical Analysis of Broadband Radomes," Internal Report, Nanjing: Ministry of Aeronautics and Astronautics Industry, Institute 8511, 1989, 14-15.
7. Wang Duxiang, "Analysis and Calculation of Broadband Radomes for Missiles" [Master's Thesis], Nanjing: Ministry of Aeronautics and Astronautics Industry, Institute 8511, 1990, 67-68.
8. Conti, D.A., "Broadband Radome Considerations," Proceedings of the 18th Symposium on Electromagnetic Windows, Georgia, U.S.A.: 1986, 91-101.

Computer-Aided Measurement of EM Parameters of Microwave Absorbing Materials

946B0157B Beijing DIANZI KEXUE XUEKAN
[JOURNAL OF ELECTRONICS] in Chinese
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[Article by Shen Xiuying [3088 4423 5391] and Zheng Ji [6774 2060] of East China Normal University, Shanghai 200062, and Gu Longdao [7357 7127 6670] and Li Peizhi [2621 0160 5347] of the Shanghai Institute of Metallurgy, Chinese Academy of Sciences, Shanghai 200050: "Computer-Aided Measurement of EM Parameters of Microwave Absorbing Materials"; MS received 23 Sep 92, finalized 28 Sep 93. (Shen Xiuying: female, born 1936, Associate Professor; currently engaged in the study of microwave computer-aided testing (CAT) techniques, microwave circuit design and CAD. Zheng Ji: male, born 1969, Master's degree student. Gu Longdao: male, born 1936, senior engineer; currently engaged in research on fine-grain iron powder and microwave absorbing materials.)]

[FBIS Translated Excerpt] Abstract: The electromagnetic (EM) parameters of microwave materials provide an important performance measure of the absorbing agent. In this paper, a new method of reconstructing EM parameters by solving the back scattering problem is presented. The traditional impedance method uses "just enough" data to solve for the EM parameters; it does not use the "residual" data to provide an overall assessment of the EM properties of the material. The method presented in this paper involves an optimized algorithm which uses both network parameters and multiple impedance measurements. Automatic measurements of EM parameters are performed on the measurement line using computer-aided techniques. Experimental results of standard test samples and absorbing materials are given.

1.0 Introduction

With the increasing application of microwaves in electronic countermeasures and aviation, the development and use of microwave absorbing materials are growing constantly. The electromagnetic (EM) parameters (complex dielectric constant, complex permeability) provide an important performance measure of the absorbing agent; they are also the basic parameters used in designing stealth coating materials.

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The conventional method of measuring EM parameters is the open-circuit, short-circuit method.^[1] Because of the difficulty in obtaining precise open circuits, some researchers have proposed the pseudo open-circuit, short-circuit method and have presented detailed error analysis of the method;^[2,3] but this method still derives the results using "just enough" data. In recent years, the development of the network analyzer has led to the scattering parameter method;^[4] researchers in this country have proposed the measurement-line method for measuring the scattering parameters and deriving the EM parameters.^[5] But this method is subject to the limitation that the scattering parameters are only obtained on the measurement line.

We believe that the parameter reconstruction problem can be treated as a back scattering problem. The key to solving this problem is to address the issues of inadequate target information and noise disturbances. This paper presents an optimized algorithm which involves both network parameters and multiple impedance measurements, and uses "residual" data to evaluate the EM performance of absorbing materials. The EM parameters on the measurement line are measured using a computer-aided measurement technique.

2.0 Basic Principle

In general, microwave absorbing material is a composite material; if the composite elements are isotropic and homogeneous, then its EM parameters can be represented by the equivalent complex dielectric constant (permittivity) and the equivalent complex permeability. We have studied a test sample of homogeneous absorbing material whose cross section is matched to the microwave transmission line. Given the thickness d of the test sample, the problem is to measure the EM parameters at the operating frequency f .

$$\epsilon_r = \epsilon' + j\epsilon'', \mu_r = \mu' + j\mu''.$$

As shown in Figure 1, we know from transmission-line theory that the input impedance at the cross section AB can be expressed as:

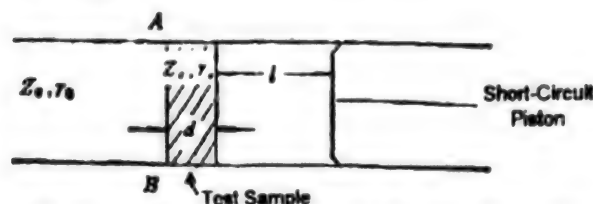


Figure 1. A Model for Measuring the EM Parameters of Absorbing Material

[Passage omitted]

3.0 Discussion of the Optimization Method

The quadratic form of the objective function leads to a nonlinear least-squares problem which can be solved using the Levenberg-Marquardt (L-M) method.^[7] This method is an improved gradient method, and it requires that the number of impedance measurements must be greater than the number of variables to be optimized. In practice, the

objective function is very complicated, and the application of the L-M method may be unstable because it requires the computation of a matrix of first-order partial derivatives (the Jacobi matrix) which contains high-order pseudo singularities. Therefore, one can consider the use of a more stable unconstrained direct optimization method—the simplex method; but a deficiency with this method is the problem of local convergence.

There are two issues that should be addressed in the multiple impedance measurement optimization problem. The first is to determine the number of impedance measurements. Study has shown that if the load is provided only by the short-circuit piston, convergence is quite slow; typically, several tens of measurements are required. By connecting a matched load to the test sample, S_{11} of the network can be accurately determined and the convergence speed is greatly increased; typically, only a dozen measurements would be required to achieve the corresponding optimization accuracy. The second issue is concerned with the imperfection of the matched load. According to microwave network theory, the measured reflection coefficient of the test sample is equal to S_{11} only if the reflection coefficient of the matched load Γ_L is zero, otherwise a measurement error exists. Since the microwave absorbing material is a lossy transmission line, the EM wave is significantly attenuated as it passes through the test sample. Study has shown that as long as the standing-wave ratio of the matched load is less than 1.05, the effect on the test results for high or medium-loss test samples is quite small. However, for low-loss samples such as polytetrafluoroethylene, the reflection of the matched load must be considered. [Passage omitted]

4.0 Test Results and Analysis

Figure 3 shows the block diagram of a PC-486-based X-band (waveguide-type) computer-aided measurement system.

The test results for polytetrafluoroethylene are as follows: $f = 9.495$ GHz, $d = 0.97$ cm.

The measured results using the multi-point optimization method and compensating for imperfection of the matched load are:

$$\epsilon_r = 2.045 - j0.005, \mu_r = 1.002 - j0.001.$$

The measured results using the open-circuit, short-circuit method are:

$$\epsilon_r = 2.161 - j0.132, \mu_r = 0.969 - j0.035.$$

If the multi-point optimization method is used without compensating for imperfection of the matched load, the results are:

$$\epsilon_r = 2.106 - j0.057, \mu_r = 0.990 - j0.015.$$

Polytetrafluoroethylene is known to be a pure dielectric medium whose EM parameters are:

$$\epsilon_r = 2.05 - j0.000, \mu_r = 1.000 - j0.000.$$

Comparison of the above results with the known EM parameters clearly shows the superiority of the optimization proposed in this paper.

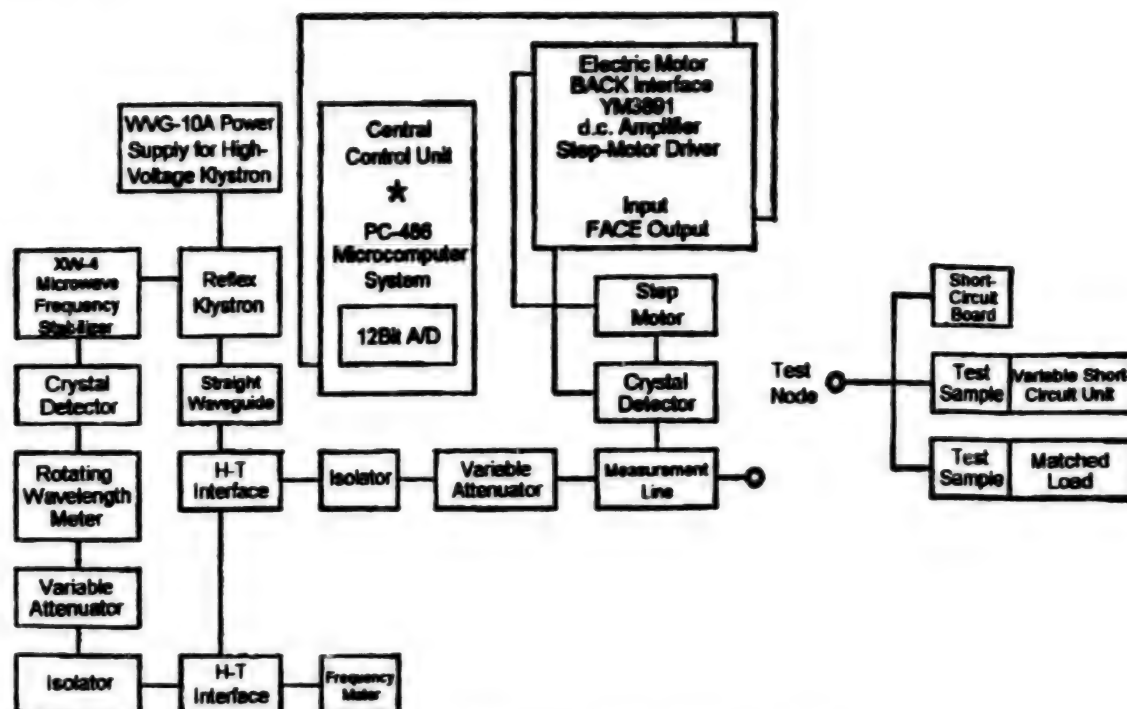


Figure 3. Block Diagram of the Measurement System

We have also tested other microwave materials; the results are shown in Table 1 ($f = 9.000$ GHz). The HP8510 automatic network analyzer is used by Institute 203 and Institute 207 of the Ministry of Space Industry to measure the S parameter of the equivalent network from which ϵ_r , μ_r are computed. It can be seen from Table 1 that there are discrepancies in the test results even when they are obtained using the same equipment and the same

approach, particularly in the imaginary parts of the dielectric constant and permeability; this is because the imaginary parts of the EM parameters are typically one order-of-magnitude smaller than the real parts, and therefore highly sensitive to measurement errors during test. A comparison shows that the results obtained by the method of this paper are basically in agreement with the results obtained by Institute 203 and Institute 207.

Table 1

Name of Test Sample	Test Unit	Dielectric Constant	Permeability
V	Method proposed in this paper	15.61-j1.03	1.43-j0.78
	Institute 203	16.17-j1.21	1.48-j0.88
	Institute 207	15.57-j1.33	1.48-j0.89
Ferrite #29	Method proposed in this paper	8.77-j0.68	1.55-j0.25
	Institute 203	8.80-j0.77	1.54-j0.45
	Institute 207	9.04-j0.92	1.57-j0.39
Composite iron powder #5	Method proposed in this paper	9.61-j0.42	1.20-j0.21
	Institute 203	9.43-j0.24	1.16-j0.21
	Institute 207	9.34-j0.40	1.19-j0.25
Ultrafine powder	Method proposed in this paper	6.25-j0.87	1.70-j0.10

5. Conclusions

The optimization method proposed in this paper involves both network parameters and multiple impedance measurements; it uses "residual" data to provide an overall assessment of the EM parameters of microwave absorbing materials. By treating the test sample as a two-node network, the value of S_{11} can be accurately determined, and

the "signal to noise ratio" of parameter reconstruction can be significantly increased. Therefore, this method is superior to the open-circuit, short-circuit method or the pseudo open-circuit, short-circuit method.

References

1. Zhou Qingyi, "Microwave Measurement Techniques," Beijing: Defense Industry Publishers, 1964, Chapter 8.

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2. Wang Xiangyuan, et al., DIANZI CELIANG YU YIQI XUEBAO [JOURNAL OF ELECTRONIC MEASUREMENT AND INSTRUMENTS], 1989, 4(1): 43-49.
3. Ibid., pp. 50-60.
4. "Measuring Dielectric Constant with the HP 8510 Network Analyzer. The measurement of both permittivity and permeability of solid materials," HP Product Note 8510-3.
5. Liang Changhong, et al., DIANZI XUEBAO [ACTA ELECTRONICA SINICA], 1990, 18(3): 1-6.
6. Liang Changhong, "Microwave Calculations," Xian: Northwest Institute of Telecommunications Engineering Publishers, 1985, Chapter 2.
7. Deng Naiyang, "Unconstrained Optimization Methods," Beijing: Science Publishers, 1982.
8. Roussy, G., THE JOURNAL OF MICROWAVE POWER AND ELECTROMAGNETIC ENERGY, 1990, 25(2): 67-73.

DGF Theory of Spherical Multilayered Chiral Media

946B0157C Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese
Vol 22 No 6, Jun 94 pp 64-71

[Article by Yin Wenyan [1438 2429 6056] and Li Pao [2621 3517] of Northwestern Polytechnical University, Xian 710071: "Dyadic Green's Function Theory of Spherical Multilayered Chiral Media, Its Applications"; MS received Jan 92, finalized Jul 92. This work was funded by the National Natural Science Foundation and the Aeronautical Foundation]

[FBIS Translated Excerpt] Abstract: In this paper, the method of scattering superposition is used to derive the Dyadic Green's Function (DGF) of an electric current source in spherical multilayered chiral media. The radiation properties and normalized radiation impedance of a point dipole antenna located at the center of a chiral spherical shell are analyzed. The effect of chirality admittance on the transmittance properties of the chiral spherical shell is investigated using the plane-slab approximation; in addition, the far-field polarization properties of the point dipole antenna under the condition of matched impedance between the external surface and the surrounding air are also discussed. The results show that the polarization state of the radiation field can be regulated by changing the normalized thickness of the chiral spherical shell.

I. Introduction

During the past few decades, the Dyadic Green's Function (DGF) method has been widely used in solving problems in electromagnetic (EM) theory and in engineering applications; in particular, it is a powerful method for solving boundary-value problems with active sources. The key issue in applying this method in EM theory and engineering applications is to determine the corresponding DGF.

The problem of interaction between chiral media and EM waves has attracted increasing attention because of the important role it plays in EM theory and in its application.^[1,2] A chiral medium is a dual isotropic medium whose constitutive equation can be expressed in the form: $D = \epsilon E + i\xi B$, $H = \xi E + B/\mu$. Here, it is assumed that the time factor of the time-harmonic field is $\exp(-j\omega t)$; ξ is called the chirality admittance, which is a measure of the degree of coupling between the electric and magnetic fields in the chiral medium. In 1990, N. Engheta, et al.^[3] first applied the eigenfunction expansion method to derive the DGF expansion in a spherical chiral medium from which the radiation characteristics of a chiral sphere in air are analyzed. A. Lakhtakia, et al.^[4] also analyzed the radiation characteristics of a dipole antenna located at the center of the chiral sphere using another form of the constitutive equation. More recently, J. A. Kong, et al.^[5] first derived the frequency-domain DGF expression in a multi-layered chiral medium; A. Toscano, et al.^[6] derived the frequency-domain DGF for a chiral slab with metal substrate. However, because of the complexity of the eigenfunction expansion of DGF in any orthogonal coordinate system, the theory and application of DGF in a bounded chiral medium is still a very difficult problem.

In this paper, the expression of DGF of an electric current source in a spherical multi-layered chiral medium is first derived; then the radiation characteristics and the transmittance properties of a dipole antenna located at the center of a chiral spherical shell are analyzed. The model given in Ref. [3] can be considered a special case of the problem presented in this paper. [Passage omitted]

IV. Transmittance Properties of a Chiral Spherical Shell

When a vertically polarized plane EM wave impinges vertically onto a chiral slab with thickness d , the direction of polarization of the transmitted wave undergoes a rotation; the co-polarized transmittance, the cross-polarized transmittance, and the co-polarized reflectance can be derived from the equations given in Ref. [7]. The transmittance properties of a single-layer chiral spherical shell under the slab approximation ($2\pi a/\lambda$) are shown in Figure 4. It is clear that $T_{\text{co-polarized}}$ has a maximum value at $\xi_2 \approx 0.0185$ mho; however, as ξ_2 varies, $T_{\text{co-polarized}}$ has more than one peak. Therefore, the chiral spherical shell has good transmittance properties.

Furthermore, the introduction of chirality admittance makes it easy to achieve impedance matching between the surfaces of two different chiral media or between the surface of a chiral medium and air.^[3,8,9]

[Passage omitted]

V. Conclusion

The DGF derived in this paper can be used for studying other problems such as the transmittance properties of chiral spheres, the field distributions of the Luneberg lens and the Maxwell fisheye lens of a chiral sphere, and the scattering properties of a metallic sphere covered with

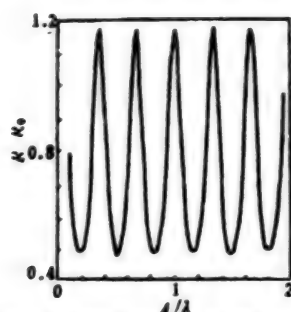


Figure 3. Variation of Normalized Radiation Impedance with the Thickness of Spherical Shell for Point Dipole Antenna

$f = 10\text{GHz}$, $\epsilon_2 = 2.25\epsilon_0$, $\mu_2 = \mu_0$, $\xi_2 = 10^{-3}\text{ mho}$, $a = 0.5\text{ m}$

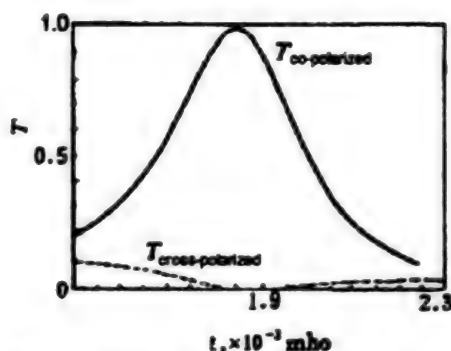


Figure 4. Effect of Chirality Admittance on the Transmittance of Chiral Spherical Shell

$f = 10\text{GHz}$, $\epsilon_2 = 2.25\epsilon_0$, $\mu_2 = \mu_0$, $\Delta = 2.1 \times 10^{-3}\text{ m}$

multi-layered chiral media. The results also show that chiral media are potentially useful materials in developing radomes.

Sincere thanks are due to Prof. Wang Wenbin for taking the time to review this paper.

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References

1. N. Engheta, D.L. Jaggard, "Electromagnetic Chirality and Its Application," IEEE AP. Soc. Newsletter. 1988, July 30.
2. A. Lakhtakia, "Simple Expressions for Scattering by a Chiral Elliptic Cylinder of Small-Cross-Sectional Dimensions," J. OPT. SOC. AM. A., 1991, 8(9): 1421-1426.
3. N. Lakhtakia, et al., "Antenna Radiation in the Presence of a Chiral Sphere," J. APPL. PHYS., 1990, 67(2): 639-647.
4. A. Lakhtakia, et al., "Radiation by a Point Electric Dipole Embedded in a Chiral Sphere," J. PHYS. D., 1990, 23(5): 481-485.
5. J.A. Kong, et al., "Spectral-Domain Dyadic Green's Function in Layered Chiral Media," J. OPT. SOC. AM. A, 1992, 9(3): 413-423.
6. A. Toscano, et al., "Spectral Dyadic Green's Function Formulation for Planar Integrated Structures with a Grounded Chiral Slab," J. OF ELECTROMAGNETIC WAVES AND APPLICATIONS, 1992, 6(516): 715-769.
7. S. Bassiri, et al., "Electromagnetic Wave Propagation Through a Dielectric-Chiral Interface and Through a Chiral Slab," J. OPT. SOC. AM. A, 1988, 5(9): 1450-1459.
8. D.L. Jaggard, et al., "Chirosorb TM as an Invisible Medium," ELECTR. LETT., 1989, 25(3): 173-174.
9. V. Varacian, et al., "Influence of Chirality on the Reflection of EM Wave by Planar Dielectric Slabs," IEEE TRANS., 1990EMC-32(4): 300-303.

Study of Height-Finding Accuracy of Bistatic Radar

946B0157D Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese
Vol 22 No 6, Jun 94 pp 100-103

[Article by Li Ruitang [2621 3843 2768], Ma Jianyue [7456 0494 1471] and Lu Kui [0712 5525] of the Department of Electronic Engineering, Xidian University, Xian 710071: "Study of Bistatic Radar Height-Finding Accuracy"; MS received Jul 92, finalized Apr 93]

[FBIS Translated Excerpt] Abstract: This paper discusses the basic principle of calculating target height using two-dimensional measurements from a bistatic radar system. The factors which affect the accuracy of height measurement are analyzed; the errors associated with the various target-height algorithms and the corresponding range of applicability are discussed. A method of correcting for the effect of earth curvature and a general approach for calculating target height are presented.

1. Introduction

Bistatic (or multi-static) radar systems have received a great deal of interest primarily because of their counterstealth capability; however, these systems have other potential applications which are being studied and implemented. The height measurement problem discussed in this paper is one of these applications.

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The bistatic radar system consists of a single transmitting station (denoted by 'TR,' usually an early-warning radar) and a receiving station (denoted by 'R') which uses digital beam-forming technology. The synchronous network and digital network between the two stations ensures the time synchronization, phase synchronization and space synchronization of the transmitted and received beams between the two stations.^[1]

Generally, both the TR station and R station have two-dimensional measurement capability: the TR station measures azimuth angle and slant range; the R station measures azimuth angle and range-sum from both stations to the target. However, because of the specific geographic configuration and strict synchronous operation of a bistatic system, it is also possible to calculate the height of a target (which may be either stealth or non-stealth target) from the two-dimensional measurements; in other words, the system has three-dimensional measurement capability. Therefore, in addition to the monitoring and early-warning functions, the system also has navigation capability inside a certain region. Clearly, this capability is of great importance for an air traffic control system or an air defense system.

The ability to measure target height is primarily determined by the relative geometry between the TR station and the R station; in practice, height measurement is possible only within a limited region of the overall coverage area of the bistatic system; furthermore, by using different combinations of measured data from the TR station and R station, different algorithms are used to calculate target height, and large discrepancies may exist between the calculated results. In the case of a long-baseline system, where the TR station is located far from the R station, the effect of Earth curvature will introduce error in the height measurement, and a correction must be applied.

In this paper, the above problems are discussed, and a general approach for calculating target height is presented, which hopefully will provide higher accuracy in the data processing of height measurements.

II. Basic Principle of Target Height Measurement

The configuration of the bistatic system under consideration is shown in Figure 1. To simplify the discussion, let us assume that the TR station is located due north of the R station, and the distance between them (i.e., the baseline) is denoted by L . For a target P , the measurements from the TR station are the slant range R_t and the azimuth angle (an angle which is complement to α_t); the measurements from the R station are the azimuth angle (an angle whose sum with α_t is equal to 360°) and the range-sum R_x ($R_x = R_t + R_r$, where R_r is the slant range between the target and the R station; it is not a measured quantity). The length of the baseline L can be determined using measurements from the Global Positioning System (GPS).

The system uses a centralized data processing mode^[2]; the processing center can be located either at the R station or the TR station, depending on the requirements of the tactical application. Also, a three-dimensional Cartesian coordinate system is established whose origin is located at the R station.

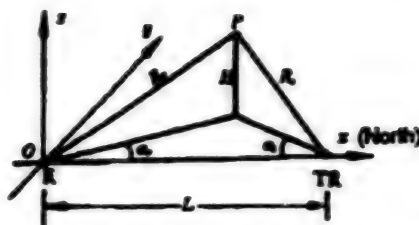


Figure 1. Configuration of the TR-R System

From the baseline distance L , the measurements (R_t , α_t) from the R station and the measurements (R_r , α_r) from the TR station, one can calculate the target height H using any four of the five data combinations. Therefore, there are 5 possible algorithms for computing the target height. [Passage omitted]

Similarly, one can derive four different expressions for computing the root-mean-square errors of height measurements (not included). These expressions show that the height-measurement error depends not only on the observation errors δR_r , $\delta \alpha_r$, δR_t , $\delta \alpha_t$, and the error in the baseline distance δL , but also on the relative geometry between the target, the TR station and the R station.

Figure 2 shows the simulation results of height-measurement errors based on the five different algorithms. The conditions for the simulation are as follows: the target is traveling at constant altitude ($H = 10$ km) in a direction parallel to the baseline ($y = 40$ km); the observation errors and the baseline data are indicated in the figure. Further simulation shows that variations in the target height have little effect on the shape of the error curve; in general, the closer the horizontal projection of the target is to the baseline, the smaller the relative measurement error.

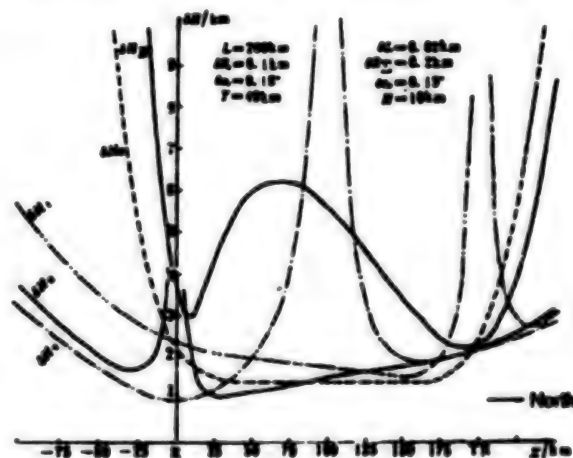


Figure 2. Error Curves of Five Different Algorithms for Computing Target Height

IV. Selection of Height-Measurement Algorithm

On the basis of equations (6)-(8) and the other four error expressions, one can analyze the relationship between each

observation error and the overall height-measurement accuracy; these results will allow guidelines to be established for selecting the accuracy requirement for each observation. But if the observation accuracies are given, one should try to find the most appropriate algorithm that would yield the best height-measurement accuracy.

Figure 2 also shows that under nearly identical conditions, different algorithms may produce very different accuracy results. For example, if the target is located between the two stations, then algorithms I, II, and IV would yield higher accuracy; if the target is located due east or due west of the R station, then algorithm IV is not applicable; if the target is located due east or due west of the TR station, then algorithm I is not applicable.

Under the condition that the target is within the system coverage area and the observation errors are specified in Figure 2, one can compare the accuracy results of algorithms I, II, III, as shown in Figure 3 (the lower half plane of the figure is symmetrical to the upper half plane). In the figure, the coverage area is divided into seven regions; within each region, the three algorithms are ranked in terms of measurement accuracy. Thus, based on the horizontal position of the target, one can choose the best algorithm for the data processing system; for example, in most of the region between the two stations, algorithm II is the preferred choice; the best region for algorithm I is near the baseline.

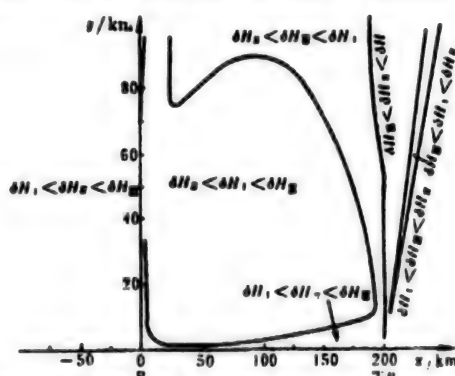


Figure 3. Comparison of Three Height-Measurement Algorithms in Different Regions Within the Coverage Area

V. Correction for Effect of Earth's Curvature

In Figure 1, the x - y plane is a plane which contains the line connecting the TR station, and the R station, and is normal to the Earth's radius. Therefore, the height H calculated from the different algorithms is referenced to this plane; it is not the actual height

$$\bar{H}$$

relative to the Earth's surface. It can be seen from Figure 4 that the actual height is

$$\bar{H} \approx H + \Delta h \quad (9)$$

where Δh is the correction term for the effect of earth curvature;

$$(\Delta h \approx \sqrt{r_0^2 + r^2 - (L/2)^2} - r_0). \quad (10)$$

Here, r_0 is the Earth's radius and r is the distance between the target projection on the x - y plane and the point O. The values of Δh can be calculated in advance and stored in a table.^[3]

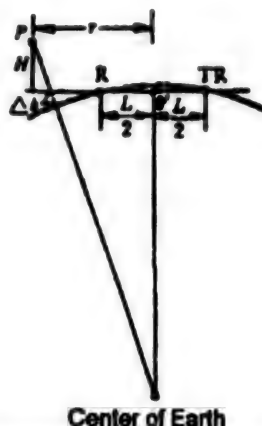


Figure 4. Correction for Effect of Earth's Curvature

VI. Conclusions

Based on the above discussion, the height-measurement procedure can be divided into the following steps:

1. Collect the measured target points from both stations and perform matching, correlation and filtering on the data to establish the target trajectory;^[4] height calculations are only carried out for points along the target trajectory.
2. Based on the trajectory data, select the optimum algorithm by referring to the regions shown in Figure 3.
3. Calculate the target height H .
4. Based on the target position, determine the correction Δh from the correction table, and compute the actual height.

$$\bar{H}$$

5. Output the height data (or apply smoothing to the data first, if necessary).

The above procedure has been implemented on a digital computer.

References:

1. E. Hanle, "Survey of Bistatic and Multistatic radar," IEE PROCEEDINGS, 1986, 133:587-595.
2. A. Farina, S. Pardini, "Survey on Multi-Radar Tracking Systems", Italy: Selenia, 1985: 13.

3. Ma Jianyue, "Design and Analysis of Bistatic Radar Data Processing System" [Master's thesis], Xian: Xidian University, 1992.
4. A. Farina, F.A. Studer, "Radar Data Processing (I)," UK: Research Studies Press LTD, 1985: 131-142.

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Prospects for Development of China's Space Technologies Reviewed

946B0163A Beijing ZHONGGUO HANGTIAN

[AEROSPACE CHINA] in Chinese

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[Article by Zhang Rufan [1728 3067 5400], Standing Committee Member and Deputy General Secretary of Beijing City Political Consultative Conference, and Standing Committee Member and General Secretary of Beijing City Democratic League: "Development and Future Prospects of China's Space Technology"]

[FBIS Translated Excerpt]

2. Development and Accomplishments of China's Space Technology

The development of China's space technology is one of its great achievements in science and technology. It not only has provided a major impetus to China's modernization and defense buildup, but also has been an important factor stabilizing the world situation and balancing world military strength. This was the result of correct policy choice by the older generation of revolutionaries, including Mao Zedong, Zhou Enlai, and Nie Rongzhen. Comrade Deng Xiaoping has stated: "Without China's two bombs and one satellite, we would not rank as a power." This is Comrade Deng's lofty affirmation of the major effect that China's development of space technology has had on international relations and the military struggle. Thus it is clear that the development of space technology is important not only in raising the people's material and cultural level, developing science and technology, and guaranteeing the security of the country, but also in preserving world stability and maintaining world peace.

China's development of space technology was entirely different from that of the United States and the former Soviet Union, and also from that of Western Europe and Japan. As everyone knows, during the 1950's, the People's Republic of China had just been founded and was in a period of economic recovery. China's science and technology were extremely backward, the overall level of industrialization was very low, and agriculture was little advanced beyond primitive methods of cultivation. In short, in both economic strength and its S&T capabilities, China was then no match for the United States, Western Europe, and Japan. Internationally, some important developed countries refused to recognize China and imposed a political, economic and technological blockade in a futile attempt to isolate China. They stationed millions of troops around our borders and created a military encirclement of China. The appearance of strong red political power changed the entire world situation and made the old and new imperialists unhappy. The party Central Committee, headed by Chairman Mao Zedong, analyzed the domestic and foreign situation with great foresight and devised the strategy of independence and self-reliance. The people arduously built up the country, not only weathering the period of difficulties, but achieving rapid development of the space industry and nuclear industry, which are recognized as among the world's most sophisticated technologies. In addition to its decisive effect in maintaining world peace and breaking the hegemony of the United States and Soviet Union, it brought inestimable social and economic benefits to China's S&T development (especially military high technology) and its socialist economic development. China's development of space technology constitutes an undying achievement. Under the unified leadership of the central authorities, the country was treated as a "single chessboard," and socialist cooperation was instituted on all fronts. By the joint efforts of engineering and technical personnel, cadres, and blue-collar workers in the aviation sector, China developed short-range missiles, medium-range missiles and intercontinental missiles, thus laying the technological and material groundwork for its launching of satellites.

The comrades of the Chinese Academy of Launch Vehicle Technology (CALT) and the Shanghai Institute of Aviation Technology, working with extremely simple and crude facilities, developed the Changzheng [Long March] model 1, 2, 3, and 4 rockets and the CZ-2 strap-on launch vehicle. This formed the basis for the development of space technology. Since the successful launching of the Dongfanghong-1 satellite on 24 April 1970, China has launched 35 independently-developed satellites. They include series of scientific satellites, technology satellites, space probe satellites, ground observation satellites, communications satellites, and weather satellites. China's achievement of immense social and economic benefits with very limited expenditure promoted social and technological progress and greatly increased the country's overall strength, but even more importantly, it changed the world's image of the Chinese people, strengthening the country's prestige and increasing the people's confidence.

China's Changzheng series is among the world's most reliable and technologically stable booster rockets. These

rockets have been used to place Chinese satellites in low orbits, sun-synchronous orbits, and geostationary orbits, and have been used in the launch and recovery of micro-gravity experimental apparatus for the MBB Corporation of West Germany and the Matra Corporation of France. In addition, they were also used to launch satellites as main or auxiliary payloads for the Asia Satellite Communications Company, headquartered in Hong Kong, and for Australia, Sweden, and Pakistan. Several companies, including U.S. companies, have signed contracts to use China's Changzheng series of satellites to launch satellites. The establishment of Chinese booster rockets as one of the major launch tools on the world satellite launching market and their bold entry into the international commercial launching market came as a surprise to many space powers, which were made uneasy by so powerful a competitor. From the beginning, some countries tried various means to choke off the fledgling program. But owing to the reliability and stability of Chinese booster rockets and their much lower prices than those current on world markets, they won recognition from industry representatives throughout the world and penetrated world markets. China's CZ-2 strap-on booster can place a 9200-kg spacecraft in low orbit, which means that China has the capability to launch small spacecraft. Foreign space experts rate this achievement very highly.

Although China's development of applications satellites was not as rapid as the development of booster rockets, this activity too had an important effect on China's economic development and defense buildup. China already has families of ground observation, scientific, technological, communications, and weather satellites, which have obtained large amounts of scientific and technical data. It has also performed numerous microgravity experiments, some using animals, plants, and microorganisms. Chinese satellite photographs are widely used in land surveys, the routing of highways and railroads, environmental analysis, mineral prospecting, disaster forecasting, and national security. They have been well received by all organizations that have used them. The social and economic benefits of communications satellites are even more inestimable.

Since reform and opening to the outside began, China's satellite launch centers at Jiuquan, Xichang, and Taiyuan have been opened to outsiders and have received friends of many colors from numerous countries; some of the visitors have watched the entire satellite launch process. CALT and the Chinese Academy of Space Technology (CAST) have received visitors from dozens of countries and regions, including space technology specialists from Taiwan Province and important governmental and military figures from several countries. In addition, China's cooperation with other countries in space technology is gradually reaching a high level: an example is the Chinese-Brazilian joint investment in the development of a technologically advanced resource satellite. In the last decade, China has exhibited at major international aerospace expositions at Paris, Farnborough, Singapore and Hannover. In November of 1991, China's exhibit of a full-size booster rocket and satellite at an international space exposition at Wanzhai, Hong Kong, attracted world attention. The exposition at Hong Kong was packed, and one out of every 10 residents of Hong

Kong visited it. In addition, Taiwan, Singapore, and countries of Southeast Asia sent people to the exposition, providing abundant evidence of its influence.

Several dozen Chinese space experts have been made academicians or corresponding members of the World Institute of Space Flight, and some have also been elected to leadership points in the International Space Flight Organization. All of these facts indicate that China's achievements in space technology are known throughout the world and that China has joined the ranks of the world powers in space.

3. Shortcomings and Considerations

Although China has had great accomplishments in space technology and has attracted world attention, it is still far behind the United States and the former Soviet Union. Recently, Western Europe and Japan have been moving ahead rapidly in space technology and have made breakthroughs in launch vehicles and satellites, overtaking China in certain fields. Such developing countries as Brazil and India are also up and running and are moving into the ranks of the leaders. These facts represent a challenge for China, and we must not take them lightly.

There are respects in which China is lagging behind: the applications satellites that China has launched are few in number and the full range of types is not available, so that they do not fully meet all of China's needs. China has thus far done nothing in the fields of interstellar probes and manned space flight. No Chinese space vehicles or space shuttles have appeared in the vastness of space, nor have there been Chinese space stations or space laboratories. Neither interstellar probes nor the commercialization, industrialization and populating of space that will occur during the 21st century appear to have been fully incorporated into space development programs. In this respect we are far behind the United States, Western Europe, and the former Soviet Union.

From another viewpoint, the breakup of the Soviet Union has put an end to the Soviet-US space rivalry and to the contest for the militarization of space, and the US "Star Wars" program has had funding cutbacks and is shrinking in scale, but this does not mean that space will be forever peaceful; even less does it mean that space technology will come to a halt. The 21st century will be a period of further development of science and technology, and space technology will move toward the industrialization and commercialization of space; in particular, it will make the populating of space into a reality. Developing and using the resources of space in the service of mankind represent an objective toward which the countries of the world are striving. Thus China must perfect its series of applications satellites and also must add new families of satellites; in addition, it must improve the technological quality and capabilities of its satellites, gradually satisfying the needs of China's various sectors and in addition striving to penetrate world markets as rapidly as possible. At the least, it must eliminate the need to rent transponders on foreign communications satellites. At the same time, China must vigorously develop spacecraft and space stations and must

make effective technological preparations for the populating of space in the 21st century, thus making the dream of "Chang'e's flight to the moon" a reality.

China now has many space research organizations and engineering and technical personnel, but owing to inadequate funding and insufficient assignments, only about a third are actually involved in advanced studies, design selection studies, and the engineering management of space systems. Many research organizations are working at only about half-capacity. This means that half of the space systems personnel and organizations have gone to the market. In other countries that are developing space technology and making use of their advantages in high technology, some personnel and technologies go directly to the market and serve society. Space technology is by its nature both a military and civilian technology, unlike nuclear weapons, which are purely military systems. Thus this situation is normal. The question that arises is what attitude we should take toward the development of space technology as we enter the 21st century. How are we to maintain China's position as a major power in space? How are we to motivate the existing engineering and technical personnel in space-related fields? How are we to keep pace with the advance of world space technology?

We must focus on the 21st century. In other words, we must focus on developing the resources of space and on the populating of space. There is a proverb that "He who does not advance falls back": everyone who stops moving forward and tries to maintain his current superiority is likely to lose it. Time marches on, and science and technology are becoming ever more dynamic. Nobody could have imagined that world space technology could have achieved such great progress in a few short decades. When we enter the 21st century, it will not be enough for China simply to launch a certain number of application satellites or to develop a few more types of satellites. If we do so, we will assuredly not be able to keep pace with world progress in space technology. It is not a matter of having Chinese launch vehicles launch a few more satellites or of obtaining such-and-such an amount of hard currency: we must consider the space markets of the future. A US industry representative estimates that in the 25-year period from 1985 to 2010, Intelsat will have earnings of \$340 billion from communications services alone. In addition, world earnings from space energy will be between \$200 and \$600 billion, total earnings from space materials processing will reach \$64 billion, and total earnings from space travel will be \$1.5 billion. The aggregate total may exceed \$1 trillion. The Microgravity Corporation in the US estimates that within 20 years, the use of the microgravity conditions of space for crystal growing alone will achieve an annual output value of US \$100 billion.

This confronts us with a question that merits deep consideration: What will be the Chinese space industry's share in the huge and enticing earnings cited above? How are we prepared to enter this attractive international space market? I believe that, owing to insufficient funding of space technology in China, many technologies have not yet been considered and we are ill-prepared to engage in international competition. China has 22 percent of the

world's population and only 7 percent of its arable land, and its other resources are not very abundant. If we do not develop the resources of outer space and if we fail to plan for their exploration, we will be poorly prepared to keep up with the overall world pace. The resources of outer space are the common wealth of mankind, and we must develop them vigorously rather than leaving other countries to profit from them.

From another viewpoint, under ordinary conditions, expenditures and output are proportional. The space industry in particular needs large expenditures to produce high output, as has been demonstrated by the development of space technology over several decades. In recent years, the United States has been spending about \$15 to 20 billion annually to develop space technology, and as a result of many years' effort, its technology is advancing rapidly. It has been able to use the Space Shuttle to place satellites in orbit and to recover them, as well as to repair the Hubble Telescope in space; it has made a soft landing on the moon, and it has sent probes to other planets. In such areas as satellite communications, ground observation, navigation, and global positioning, the sophistication of its techniques could have been obtained only by continuous improvement and progress. If the US had inadequate investments in space, it would not have been able to realize such great economic benefits and technological advances.

US communications satellites now have 36 transponders, whose lifetime may be 10 years or more. INTELSAT-8 has a total of 44 transponders, including 38 in the C band and 6 in the Ku band. Our communications satellites have only four communications transponders, with a lifetime of only 7 years. Even the Dongfanghong-3 (DFH-3) communications satellite has only 24 transponders, equivalent to US technology at the beginning of the 1980's. Because China's communications satellites cannot meet domestic needs, we are compelled to use foreign companies' communications transponders or even their satellites. We must be aware of our deficiencies and we must rapidly increase our investments in space and find a path of development of space technology that is suited to China's conditions.

4. Making Use of Advantages to Produce a New Flowering

China's space technology has distinctive advantages. What are they? The first is our consistent self-reliance in developing space technology, with reform and opening to the outside enabling us to absorb successful foreign experience. The second is planning on a national scale, making use of the socialist lack of concern for fame and wealth, and engaging in large-scale cooperation. The third is that China has trained a large body of advanced personnel in space technology. The fourth is that China's space facilities and large-scale space engineering projects are essentially Chinese-developed and designed and have domestic roots. The fifth is that China has a fully rounded space engineering system that includes scientific research, production, experimentation, launching, measurement and control, and data processing. The current problem is how to expand upon these advantages and to use them so as to keep pace with world space technology. If we cannot make adequate use of

our advantages, we not only will be unable to create powerful forward momentum, but the program may become a heavy burden. For example, every year, China's main satellite assembly plant produces only a few satellites, its booster rocket assembly plant produces only a few rockets, its launch areas launch only a few satellites, and its telemetry systems are used only a few times. It is clear that their economic effectiveness is too low, that the cost-to-benefit ratio is too high, and that the rate of upgrading of personnel and technologies is slow. The tasks that we perform in a year are equivalent to those carried out in a month or even a week by the US and the former Soviet Union. There is no doubt that this problem must be conscientiously dealt with.

The current situation is that China's space technology is approaching maturity and we have a large body of expert personnel. The key problem is that new projects are not set in motion in time, and as a result our ablest personnel have no scope for the exercise of their talents. In addition, we must be aware that some of our key technologies require further breakthroughs and exploration. Even more importantly, we must quickly begin increasing space-technology funding every year; if we do not solve this problem, China's space technology will not develop fast enough and will fail to progress, so that in addition to being unable to keep up with the United States, Western Europe, and Japan, we may even fall behind Brazil and India. The world is following this subject, and several countries are watching China, not without reason.

It must be admitted that since the Third Session of the 11th CPC Central Committee, our economic development has been rapid, the country's overall strength has been greatly increased, and the people's lives have been greatly improved. But the country still must provide large amounts of aid to the old, to the young, and to border areas and poor areas. There are still 80 million persons who lack basic necessities. Every year nearly a million children are unable to go to school, and in 1993 nearly 20 provinces actually could not pay primary and secondary teachers' wages. These are China's circumstances. Thus, at this point, it might seem reasonable that a decision cannot be made to increase investments in China's space industry. But if we take the long view, in order to escape from China's poor and straitened circumstances and to improve people's conditions of life, it is not entirely out of the question to save a little in some areas, such as buying fewer imported automobiles and stopping or decreasing publicly funded meals and travel abroad, in order to increase our investment in space technology.

At this point, we are still being overcautious toward increasing space investments and developing space. This situation is very closely related to China's traditional concepts and economic strength. It would of course be wrong to ignore the realities of China's situation, but it is also wrong to ignore the future and to fail to take thought for future generations. Global resources are limited and the population is continuing to grow. By the middle of the 21st century, China's population will approach 2 billion. Faced with the prospect of such a large population, if we do not

find an avenue of escape outside the earth, and if we fail to seriously consider the future, disastrous problems may result.

To maintain China's position as a major power in space, we must conscientiously examine the grim situation that is now facing China's space personnel, continue to make use of our advantage, and eliminate or decrease our disadvantages. Henceforth, we must prepare for comprehensive development of the resources of space. Building on the development of applications satellites, we must rapidly develop spacecraft and build space laboratories. Provided that the country increases its expenditures, realizing the desire to further develop space is only a matter of time. If we hesitate and lose our current advantages in skilled personnel, or if we put off making a decision, the problem may become complicated. If we lose the opportunity and lose our advantage in personnel, money will be even harder to come by (or programs will be stretched out excessively). This would be a great loss.

Conclusion

The development of China's space industry is now in a key period. If we can attract the interest of China's government and people and speed up development, when we enter the 21st century, China's space program will assuredly have a second flowering. By that time, not only will a variety of Chinese-made applications satellites be in outer space, but Chinese manned spacecraft and space laboratories may also be there. Chinese "space hotels" may come into being, allowing ordinary people to take to the skies and enjoy the experience of space travel. By that time, the earth will no longer be humanity's sole habitat. If we continue with business as usual, failing to accord the full importance to increased investment and to the thorough use of personnel advantages on the space front, and if we do not thoroughly motivate all of the parties involved, then when the 21st century comes, China may fall from the ranks of the major powers in space. The time to choose our course is now at hand. Will China's space technology be able to have a second flowering as it enters the 21st century? This is a subject that is on everyone's mind.

Strategic Missile Simulation Training System Developed

946B0151B Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 27 Jul 94 p 1

[Article by Chang Bo [4453 0590] and Zhang Jiajun [1728 1367 6511]]

[FBIS Translated Text] The strategic missile simulation training system is a high priority key project of the PLA. Experts described the system as "combining the war time and peace time use of strategic missiles, integrating their training and deployment, and effectively improved their survivability." This system has just been certified by army and civilian experts at the Second Artillery Engineering College. The emergence of this system filled a void in China's strategic missile simulation. It provided a superior and less costly approach and provided technical assurance

that China would under no circumstance be the first one to use strategic nuclear weapons.

A concept that received recognition and praise was advanced by Huang Xianxiang [7806 0341 4382], professor of the Second Artillery Engineering College and expert on launching and targeting. Professor Huang believed that China must put more efforts into simulation in order to improve its strategic missile survivability. In the early 1990s, the Headquarters and the Second Artillery Engineering College assigned the project to the research group headed by Huang. Huang's group carefully studied existing knowledge and addressed the difficult problem of costly training with real ammunition. They cleverly combined simulation and mock training and conquered more than 20 major technical problems including electrohydraulic control and information cryptology. They drafted more than 4,000 design drawings and wrote almost 10,000 lines of

software. The project produced more than 30 technical information described by 400,000 some words.

After rigorous and careful evaluation, the experts felt that the project made integrated use of optimization theory, modern hydraulic engineering technology, electronics technology, transduction methods, and computer science. The project has solved a number of difficult problems along the way and achieved the technology of combining training and simulation. The system is not only a high security simulation device but also a realistic training simulator. The building cost is only one tenth of the original equipment but the service life will be many times longer. The system has major military and economic benefits in terms of improved survivability of China's strategic missiles, and modernization of the training of China's strategic missile units.

**Nucleotide Sequence and Structure Function
Analysis of Complete E3 Region of Adenovirus
Type 4**

40091002A Beijing BINGDU XUEBAO [CHINESE
JOURNAL OF VIROLOGY] in Chinese
Vol 10 No 3, Sep 94 pp 197-208

[English abstract of article by Tan Weiyan [6223 4850
1750] and Ruan Li [7086 0500], Institute of Virology,
Chinese Academy of Preventive Medicine, Beijing]

[FBIS Transcribed Text] The DNA fragment of Ad4 genome which ranges from 73.3m.u. to 89.2m.u. including the whole of Ad4 E3 region and part of the flanking regions has been sequenced. The sequence analysis showed that there are a total of 4,778 base pairs in the Ad4 E3 region, calculated from the beginning of TATAA box to the end of E3b poly A site, in which 11 open reading frames (ORFs) coding for proteins with molecular weights over 6kd are located. An analysis of ORFs indicated that the ORFs of Ad4 E3 code for proteins of 19.3kd, 15kd and 10.4kd, corresponding to proteins of gp19kd, 14.7kd and 10.4kd of Ad2 E3, respectively. The E3 region of Ad4 shares comparatively high nucleotide homology with those of Ad2 and Ad3, 50-55% and 55-60%, respectively, much higher than the homology of the whole genome of Ad4 with those of other subgroups (4-23%). Although the E3 region is nonessential for viral replication in cell culture, the facts that E3 regions are maintained in various types of adenoviruses and possess similar gene structure and high homology indicate that the E3 region has very important functions in virus infection.

**Establishment of Human Malignant T Lymphoma
Cell Lines Carrying a Retrovirus**

40091002B Beijing BINGDU XUEBAO [CHINESE
JOURNAL OF VIROLOGY] in Chinese
Vol 10 No 3, Sep 94 pp 209-215

[English abstract of article by Lan Xiangying [5663 4382
5391], Zeng Yi [2582 3015], et al., Institute of Virology,
Chinese Academy of Preventive Medicine]

[FBIS Transcribed Text] An IL-2 independent malignant lymphoma line (CM-1) from the peripheral blood T lymphocyte donated by a female patient with nervous system diseases has been established, and the biological characteristics of the CM-1 cells was studied. The CM-2 cell line from the peripheral T lymphocytes donated by a male patient with multiple sclerosis that could be transformed into a malignant lymphoma line by using filtered supernatant of CM-1 cultured medium was also established. The CM-1 and CM-2 cells when transplanted by subcutaneous inoculation into nude mice, could cause typical malignant lymphoma. The electron micrographs revealed the existence of virions in the CM-1 and CM-2 cells, and these virions were similar to retrovirus in their ultrastructural characteristics. It was found that these cells possessed reverse transcriptase activity. Results obtained from serological assay, probe hybridization and PCR excluded the existence of other human viruses which were commonly used in this laboratory. All results in this paper showed that

this virus, which has the strong capability of malignant transformation, probably is a new retrovirus. Meanwhile, works on the cloning and sequencing of the virus genome are being carried out.

**Isolation of Human Immunodeficiency Virus
(HIV) From a Chinese Aids Patient Infected in
Beijing**

40091002C Beijing BINGDU XUEBAO [CHINESE
JOURNAL OF VIROLOGY] in Chinese
Vol 10 No 3, Sep 94 pp 216-220

[English abstract of article by Zhao Yongsan [6392 3057
2773], Zeng Yi [2582 3015], et al., Institute of Virology,
Chinese Academy of Preventive Medicine]

[FBIS Transcribed Text] A more sensitive method for isolation of Human Immunodeficiency Virus (HIV) was set up in this laboratory. The patient peripheral monocytes (PMCs), were cocultured with normal PMCs. 10% interleukin-2, 5µl of phytohemagglutinin-P per ml were added into medium (stimulation medium) in the first three days. Then the cells were cultured with 1% IL-2 in regular medium. The parallel groups did not use the stimulation medium. When a large amount of HIV-1p24 Ag was detected in the supernatant, some of the positive cells were cocultured with normal Jurkat-tat, CEM and MT4 cells. In the meantime, the patient's PMCs were also cocultured with these three cell lines directly. The method using a stimulation medium was found to be more sensitive than the others. The results were confirmed by IFA, IEA, Western blot and HIV-1 Pol and Env gene sequence PCR. The HIV-1 isolated grew rapidly in Jurkat-tat cells and caused death of cells. After 10 passages of growth, the characteristics of the virus kept stable.

**Fusion and Expression of Hepatitis B Virus PreS2
Epitope (120-145) and HbcAg Genes**

40091002D Beijing BINGDU XUEBAO [CHINESE
JOURNAL OF VIROLOGY] in Chinese
Vol 10 No 3, Sep 94 pp 221-228

[English abstract of article by Zhu Yunfeng [2612 6663
1496], Shi Chenghua [4258 2052 5478], et al., Institute of
Biotechnology, Academy of Military Medical Sciences,
Beijing]

[FBIS Transcribed Text] HBV PreS2 consists of 55 amino acids, of which the 26 amino acids at the N terminal are the Th cell and B cell epitopes. HbcAg gene including partial PreC gene was fused with chemically synthesized PreS2 epitope (120-145) gene at different sites. The fusion proteins were expressed in *E. Coli* and purified by affinity chromatography. The antigenicity of different fusion proteins were studied by ELISA and Western-blot. It was found that best retention of antigenicity of both HbcAg and PreS2 was obtained with fusion at position 144 at the C terminus of HbcAg after removal of the arginine rich region. In addition, the expression level of fusion proteins could be increased with *tac* promoter instead of *lac* promoter and different host strains have little influence on the expression level of the fusion protein.

cDNA Chimeric Fusion and Prokaryotic Expression of Nucleocapsid and NS3 Regions of Hepatitis C Virus Genome and Analysis of Its Antigenicity

40091002E Beijing BINGDU XUEBAO [CHINESE JOURNAL OF VIROLOGY] in Chinese
Vol 10 No 3, Sep 94 pp 229-234

[English abstract of article by Yang Yongping [2799 3057 1627], Jiang Yongzhen [3068 3057 3791], et al., Institute of Virology, Chinese Academy of Preventive Medicine]

[FBIS Transcribed Text] cDNA fragments of C831 (530 bp) and C33c (860 bp) encoding the putative nucleocapsid (C) CL and the nonstructural region 3(NS3) protein C33c of the HCV, have been obtained from the sera of Chinese carriers with HCV infection by reverse transcription (RT) and polymerase chain reaction (PCR) techniques. The 5' terminal of C831 cDNA fragment was linked up with the 3' terminal of NS3 cDNA fragment by a oligonucleotide linker Ser-Pro-Gly-Ser to form a chimeric gene C33c-C831 (1400 bp). The chimeric gene C33c-C831 was recombined with prokaryotic expression vector pBV220, and was expressed in *E. coli* in the form of a native chimeric polypeptide C33c-CL. The expression product was screened and detected by enzyme-linked immune solid assay and western blotting with anti-C33c serum and anti-CL serum, respectively. A chimeric C33c-CL polypeptide with a molecular weight of 53kD accounted for 9% of the total cellular soluble proteins. The expression product was extracted from the bacterial lysate by lysozyme, Triton X-100 and urea treatment and purified by ion exchange chromatography. The purified C33c-CL chimeric polypeptide was used to develop a capture assay for reactive anti-HCV antibodies. This anti-C33c-CL assay detected all previously identified HCV-seropositive cases and provides a substantially more sensitive diagnosis (99%) than any of anti-C33c (93%) anti-C22 (83%) or anti-5-1-1 (50%) for both acute and chronic HCV infections. The C33c-CL chimeric polypeptide keeps the antigenicity of both C33c and CL. Its specificity and sensitivity were all in keep with the requirements of the national standard for quality control of the HCV diagnostic kit. The C33c-CL chimeric polypeptide may have an important role in anti-HCV assay.

Partial Nucleotide Sequence of VP1 Fragment of Chinese Poliovirus Vaccine Strain Zhong II₁₇ and Zhong III₂

40091002F Beijing BINGDU XUEBAO [CHINESE JOURNAL OF VIROLOGY] in Chinese
Vol 10 No 3, Sep 94 pp 235-239

[English abstract of article by Zhang Libi [1728 4409 3880], Institute of Virology, Chinese Academy of Preventive Medicine; M. Hara and T. Yoneyama, JICA Polio program group; Zheng Hong [6774 4767], Institute of Virology, Chinese Academy of Preventive Medicine; and N. Hagiwara, NIH, Japan; This program received a part of its subsidy from the Natural Science Fund]

[FBIS Transcribed Text] A part of the polio VP1 nucleotide sequence of the Chinese polio vaccine strains Zhong II₁₇

and Zhong III₂ were analyzed. Comparison of the 417bp nucleotide sequence of Zhong III₁₇ and Sabin 2 showed, there are three nucleotide mismatches, the homology is 99.30%. The Zhong III₂ sequence is the same as Sabin 3 vaccine strain. Three vaccine-like strains of poliovirus type 2 isolated in Hainan, Shandong, Hunan provinces were similarly analyzed, these strains had 0, 1 and 2 nucleotide mismatches, respectively, with Zhong II₁₇.

A Comparison of Dot Blot Nucleic Acid Hybridization With Reverse Transcription Polymerase Chain Reaction in Detection of Serum HCV RNA

40091002G Beijing BINGDU XUEBAO [CHINESE JOURNAL OF VIROLOGY] in Chinese
Vol 10 No 3, Sep 94 pp 257-262

[English abstract of article by Yang Yongping, Cong Mianer, Xia Ningshao, Cao Jingyuan, and Liu Chongbai, Institute of Virology, Chinese Academy of Preventive Medicine, Beijing]

[FBIS Transcribed Text] In order to reach an understanding of the role of the dot blot nucleic acid hybridization in detecting HCV RNA in sera with HCV infection, serial blood samples with HCV infection were tested for the presence of the HCV genome by using the Dig-cDNA probes derived from the C and NS3 regions of the HCV genome, and the reverse transcription-polymerase chain reaction (RT-PCR). Comparison of each other indicates that both methods can detect HCV RNA in sera with HCV infection early and rapidly, but the RT-PCR is more sensitive than the dot blot nucleic acid hybridization, and the dot blot nucleic acid hybridization can improve the specificity and sensitivity of the RT-PCR method. The latter can be used as a semiquantitative method for monitoring the change of HCV RNA, and for screening high titre HCV RNA samples for experimental research. The sensitivity of both methods are related to the RNA extraction procedures, the cDNA probes used for nucleic acid hybridization and the primers used for RT-PCR. We found that HCV RNA detected by both methods appeared 1 or 2 weeks before elevation of the alanine aminotransferase (ALT) and the HCV RNA positive rate during the peak ALT was higher than that after the peak ALT. Also the HCV RNA positive rate of cases with clinical symptoms was higher than that of cases without clinical symptoms.

Role of Immune Spleen Cells in Protection Against Fatal HFRS Virus Infection in Adult Mice

40091002H Beijing BINGDU XUEBAO [CHINESE JOURNAL OF VIROLOGY] in Chinese
Vol 10 No 3, Sep 94 pp 268-270

[English abstract of article by Lu Wenhong [4151 2429 4767], Yao Chuzheng [1202 2806 6927], et al., Institute of Epidemiology and Microbiology, Chinese Academy of Sciences, Beijing]

[FBIS Transcribed Text] It was reported in the previous study that cyclophosphamide-immuno-suppressed adult

C57 mice were susceptible to HFRS virus infection. Using this animal model, the role of cell-mediated immunity in HFRS was investigated. Immune spleen cells taken from C57 mice immunized with HFRS virus (A-16 strain) were transferred to syngeneic adult mice before or after intracerebral infection with A-16 virus, to see whether the animals would be protected from death. Intravenous transfer of 1×10^8 , 4×10^7 , 3×10^7 , 1×10^7 , and 5×10^6 immune spleen cells to adult mice 2 hours before infection, resulted in 100% to 50% protection. And transfer of 1.2×10^8 and 5×10^7 immune spleen cells to mice 24 hours post infection, resulted in 100% and 66.7% protection, respectively. In contrast, transfer of nonimmune spleen cells offered to protection. The survival time of mice which received insufficient number of immune spleen cells, were longer than that of the control animals. Specific viral antigen was found in brain and lung by direct IF assay in dead mice, however, the viral antigen were scanty in the organs of the protected survived mice.

Fusion Expression Vectors for the Recombinant Gene Products Processed Easily and Purified Rapidly by the Affinity Chromatography

40091002I Beijing SHENGWU GONGCHENG XUEBAO [CHINESE JOURNAL OF BIOTECHNOLOGY] in Chinese Vol 10 No 3, Aug 94 pp 206-212

[English abstract of article by Li Boliang [2621 0130 5328], Yang Xinying [2799 2450 4481], et al., Shanghai Institute of Biochemistry, Academia Sinica, Shanghai]

[FBIS Transcribed Text] A DNA fragment encoding IgG-binding domain B, C (PABC) was separated from protein A gene, cloned into phage M13 and modified by oligo-directed mutagenesis at the hydroxylamine-cleaved site from Asn-Gly to Asn-Ala in domain B and C, respectively. The modified PABCm gene fragment was used to construct one set of fusion expression vectors in a different reading frame. Some processing sequences such as those recognized by enterokinase, collagenase, thrombin, activated factor X and cleaved by the hydroxylamine, N-chlorosuccinimide, etc., can be created in the fusion site. Using the above sectors, some fusion proteins such as PABCm-IGF-I, -hGRF, -bGRF and their derivatives were highly expressed in *E. Coli*. The yield of fusion proteins is over 100 mg per liter culture by analysis of SDS-PAGE. The PABC fusion proteins can be rapidly purified by the affinity chromatography with a IgG-sepharose 4B column.

Study of the Plasmid Instability in *Corynebacterium*

40091002J Beijing SHENGWU GONGCHENG XUEBAO [CHINESE JOURNAL OF BIOTECHNOLOGY] in Chinese Vol 10 No 3, Aug 94 pp 234-238

[English abstract of article by Na Shumin [6719 3219 2404], Shen Tianxiang [3088 1131 5046], and Jia Panxing [6328 4149 5281], Institute of Microbiology, Academia Sinica, Beijing]

[FBIS Transcribed Text] Recombinant plasmid pNAR4, which can be used as the shuttle vector between *E. Coli* and coryneform bacteria, was constructed by ligation of the DNA fragments of pNAT65 and pACYC177. Plasmid instability was found when pNAR4 was transformed into various coryneform bacteria strains, segregational instability in *C. crenatum* B9 and structural instability in *C. glutamicum* 10147 and *C. crenatum* T6-13. When pNAT65 was transformed into *C. glutamicum* 10147, the plasmid in transformants were found different to pNAT65. The size and main restriction sites in these plasmids were identical with that of pXZ10145. DNA hybridization experiments indicated that in *C. glutamicum* 10147, there was a supercoiled DNA content which was highly homologous with pXZ10145. An assumption is given here in which the existence of this supercoiled DNA content is related to the phenomena of various plasmid instability M and inter- or/and intra-molecular recombination may be the reason to explain the related phenomena found in our work.

Immunological Detection of Organophosphate Resistance of *Culex* Mosquitoes Using Anti-Esterase Monoclonal Antibody

40091002K Shanghai ZHONGGUO JISHENGCHONGXUE YU JISHENG-CHONGBING ZAZHI [CHINESE JOURNAL OF PARASITOLOGY & PARASITIC DISEASES] in Chinese Vol 12 No 3, Aug 94 pp 165-168

[English abstract of article by Zhu Huaimin [2612 3232 3046] and Qu Fengyi [4234 6646 0122], Department of Parasitology, Second Military Medical University, Shanghai; and Liu Weide [0491 4850 1795], Shanghai Institute of Entomology, Academia Sinica, Shanghai]

[FBIS Transcribed Text] Different strains of *Culex* mosquitoes (*Cx. pipiens quinquefasciatus* and *Cx. pipiens pallens*) were immunologically-detected for organophosphate resistance with anti-esterase monoclonal antibody, and the results were compared with those detected by bioassay and biochemical microplate assay. It was found that the resistance-detection-rate detected by immunologic methods were higher than the corresponding data detected by the biochemical method, and the levels of resistance detected by sandwich-ELISA were higher than the corresponding levels detected by bioassay and the biochemical method. The thresholds for resistance in sandwich-ELISA were (at absorbance 450) ≥ 0.5 , and in microplate assay were (at absorbance 590) $\geq 2.5 \times 10^{-3} \mu\text{mol/min} \times \text{mg protein}$.

The dot-ELISA method was developed to meet the requirement of the field test and proved to be fast and convenient, especially in the detection of samples with higher esterase activity.

Amplification *In Vitro* and Identification of Small Subunit Ribosomal DNA Fragment of *Plasmodium Falciparum*

40091002L Shanghai ZHONGGUO

JISHENGCHONGXUE YU JISHENG-CHONGBING ZAZHI [CHINESE JOURNAL OF PARASITOLOGY & PARASITIC DISEASES] in Chinese Vol 12 No 3, Aug 94 pp 169-171

[English abstract of article by Wan Lei [8001 4320] and Chen Peixia [7115 1014 7209], et al., Department of Parasitology, Fourth Military Medical University, Xi'an; This project was supported by the National Natural Science Foundation of China]

[FBIS Transcribed Text] According to computer analysis SSUrDNA sequences of *Plasmodium*, other protozoa and human, two oligonucleotide primers were designed. A DNA fragment, about 570 base pairs, was successfully amplified by two temperature point polymerases chain reaction from the genomic DNA of cultivated erythrocytic stage of *P. falciparum* FCC/YN (Simao), but no fragment was obtained from that of *P. vivax*, *L. donovani*, *T. gondii* and humans. It has been confirmed that the amplified fragment was indeed expected SSUrDNA segment of *P. falciparum* by means of restriction endonuclease digestion and Northern blot hybridization.

Comparative Study on Hemolytic Toxicity of Trifluoroacetoprimaquine and Primaquine in Rabbits

40091002M Shanghai ZHONGGUO

JISHENGCHONGXUE YU JISHENG-CHONGBING ZAZHI [CHINESE JOURNAL OF PARASITOLOGY & PARASITIC DISEASES] in Chinese Vol 12 No 3, Aug 94 pp 218-220

[English abstract of article by Shi Xiaohua [2457 2556 5478], Zhan Chongqing [3277 1504 3237], et al., Institute of Parasitic Diseases, WHO Collaborating Centre for Malaria, Schistosomiasis and Filariasis, Chinese Academy of Preventive Medicine, Shanghai; This project was supported by the Scientific Foundation for Youth, Chinese Academy of Preventive Medicine]

[FBIS Transcribed Text] The 5-trifluoroacetoprimaquine (M8506) exhibited high effect on tissue schizont of *P. cynomolgi* and low toxicity in mice, rats and dogs as compared with primaquine (PQ) according to our previous studies. In order to determine their hemolytic toxicity, the rabbits were dosed with M8506 and PQ at a dose of 40 mg/kg per day for 4 days, respectively. Blood samples were drawn from the ear vein of the rabbits for determining the following parameters, i.e., methemoglobin (metHb), reticulocyte (ret) and Heinz-body (Hbd) on d_0 before treatment and on d_3 , d_5 , d_7 , d_{10} , d_{14} and d_{12} after treatment. The results showed that after drug administration the levels of metHb, ret and Hbd in PQ group increased on d_3 - d_5 , and reached their peak levels on d_7 - d_{10} , and then declined gradually from d_{10} - d_{14} . The mean percentage concentration of metHb, mean count of ret and Hbd in PQ group on d_7 after medication were 22.1 \pm 21.8%, 92.0 \pm 88.0/1,000 RBC and 203.8 \pm 126.7/1,000 RBC, which

were significantly higher than those of the control (8.2 \pm 5.3%, 37.5 \pm 16.2/1,000 RBC and 57.4 \pm 45.1/1,000 RBC). In M8506 group, the mean Hbd count (196.3 \pm 123.1/1,000 RBC, on d_7 after treatment was also higher than that of the controls, but its mean metHb percentage concentration (10.8 \pm 8.9%) and mean ret count (42.2 \pm 20.3/1,000 RBC) were similar to those of the controls ($P > 0.05$). The results suggested that the hemolytic toxicity induced by M8506 in rabbits might be similar to or even lower than that induced by PQ.

Effect of Trifluoroacetoprimaquine on Erythrocytic Schizonts of Rodent Malaria

40091002N Shanghai ZHONGGUO

JISHENGCHONGXUE YU JISHENG-CHONGBING ZAZHI [CHINESE JOURNAL OF PARASITOLOGY & PARASITIC DISEASES] in Chinese Vol 12 No 3, Aug 94 pp 223-224

[English abstract of article by Ye Xiuyu [0673 4423 3768], Shao Baoruo [6730 5508 5387], et al., Institute of Parasitic Diseases, WHO Collaborating Centre for Malaria, Schistosomiasis and Filariasis, Chinese Academy of Preventive Medicine, Shanghai]

[FBIS Transcribed Text] Effect of trifluoroacetoprimaquine oxalate (M8506) and primaquine (PQ) on blood schizont of *Plasmodium berghei* were determined using the method of 4-day suppressive test within extended observation period of 60 d. When mice infected with *Plasmodium berghei* ANKA strain were treated ig with M8506 or PQ at the same daily dose of 20 mg/kg for 4 d, the cure rates were 100% and 90%, respectively. The two drugs also showed prominent suppressive effects on chloroquine-resistant *P. berghei* NS line and pyronaridine-resistant *P. berghei* RP line, but the parasitemia still remained positive for all of the mice treated recrudescence, indicating the existence of cross resistance between trifluoroacetoprimaquine and other erythrocytic schizonticides, including chloroquine and pyronaridine.

Fusion of Genes Encoding *Escherichia coli* Heat-Labile and Heat-Stable Enterotoxins

40091001A Beijing ZHONGHUA WEISHENGWUXUE HE MIANYIXUE ZAZHI [CHINESE JOURNAL OF MICROBIOLOGY AND IMMUNOLOGY] in Chinese Vol 14 No 4, Aug 94 pp 219-222

[English abstract of article by Zhang Zhaoshan [1728 0340 1472], Li Shuqin [2621 3219 3830], et al., Institute of Biotechnology, Academy of Military Medical Sciences, Beijing]

[FBIS Transcribed Text] The fusion genes, comprising the genes that code for the B subunit of the heat-labile enterotoxin (LT-B) and the heat-stable enterotoxin (STa) of enterotoxigenic *Escherichia coli* (ETEC), have been constructed by recombinant genetic techniques. The LT-B/STa fusion peptides were not only of heat-stable (ST) antigenicity but also of LT-B antigenicity. For the different constructions, the expression levels of ST antigenicity differed greatly, but LT antigenicity were similar. The fusion proteins retained the ability to bind to GM-1 ganglioside and native toxicity of STa.

Amplification and Cloning of the Gene Encoding the 14kD Protein of *Rickettsia prowazekii* Virulent Strain Breinl

40091001B Beijing ZHONGHUA WEISHENGWUXUE HE MIANYIXUE ZAZHI [CHINESE JOURNAL OF MICROBIOLOGY AND IMMUNOLOGY] in Chinese Vol 14 No 4, Aug 94 pp 223-225

[English abstract of article by Zhuang Hean [8369 0678 1344] and Fan Mingyuan [5400 2494 6698], Institute of Epidemiology and Microbiology, Chinese Academy of Preventive Medicine, Beijing]

[FBIS Transcribed Text] According to the DNA sequence of *Rickettsia prowazekii* a virulent strain E 14kD protein gene, a pair of primers were designed, the restriction enzyme EcoR I, Hind III recognition sequences were added on to the 5' ends of the primers. The 14kD protein gene of *R. prowazekii* virulent strain Breinl was amplified by PCR with the primers, the size of the 14kD protein gene DNA was 0.72 kb. The amplified 14kD protein gene DNA was digested with restriction enzymes Hind III and EcoR I, then ligated to plasmid vector pUC19 which had been digested with the same restriction enzymes. The recombinant plasmid was transferred to the competent *E. coli* JM 103. Identified by enzyme digestion and DNA hybridization, the gene encoding the 14kD protein of *R. prowazekii* virulent strain Breinl has been successfully cloned.

Cloning and Sequencing the Variable Gene From the Heavy Chain of Monoclonal Antibody Against HSV Glycoprotein C

40091001C Beijing ZHONGHUA WEISHENGWUXUE HE MIANYIXUE ZAZHI [CHINESE JOURNAL OF MICROBIOLOGY AND IMMUNOLOGY] in Chinese Vol 14 No 4, Aug 94 pp 226-229

[English abstract of article by Yu Qigui [0827 0796 2710], Qin Kefeng [4440 0344 6912], et al., Department of Microbiology, Fourth Military Medical University, Xian]

[FBIS Transcribed Text] This report describes the cloning of 1A12/4D5 V_H gene by PCR from cDNA of 1A12/4D5 hybridoma cells which secrete a mouse monoclonal antibody against Herpes simplex virus (HSV) glycoprotein C. The product, the 360bp nucleotide sequences were analyzed and the results showed that 1A12/4D5 V_H gene was probably derived from the JH4 minigene and belongs to the mouse heavy chain subgroup III D.

Cloning of Invasive Plasmid Antigen Genes From *Shigella* spp. and Construction of *Shigella sonnei* (Ipa⁺, Oag⁺) Strains

40091001D Beijing ZHONGHUA WEISHENGWUXUE HE MIANYIXUE ZAZHI [CHINESE JOURNAL OF MICROBIOLOGY AND IMMUNOLOGY] in Chinese Vol 14 No 4, Aug 94 pp 230-232

[English abstract of article by Zhang Rongping [4545 1369 5393] and Chen Enlin [7115 1869 5259], Department of Microbiology, Tianjin Medical College]

[FBIS Transcribed Text] By direct transforming the plasmid pHS4108 into a recipient strain, *Shigella sonnei* form II S₁R(Ipa⁺, Oag⁺), a recombinant strain S₁R101/pHS4108 was constructed. It was shown that S₁R101/pHS4108 was able to express polypeptides a, b, c, and d but no O antigen. By further subcloning a 12.5kb Sal I DNA fragment from pHS4108 into plasmid pBR322, a plasmid pJM56 was also constructed. This plasmid was then transformed into *Shigella sonnei* strain S₁R, thus a recombinant strain S₁R102/pJM56 was obtained. S₁R102/pJM56 was tested to be capable of expressing polypeptides a, c, d except b.

Key words: *Shigella sonnei*; Plasmid; Invasive outer membrane protein; Cloning.

The Antigenic Specificity of Meningococcal Bactericidal Antibodies Induced by *N. lactamica* and *N. meningitidis*

40091001E Beijing ZHONGHUA WEISHENGWUXUE HE MIANYIXUE ZAZHI [CHINESE JOURNAL OF MICROBIOLOGY AND IMMUNOLOGY] in Chinese Vol 14 No 4, Aug 94 pp 233-237

[English abstract of article by Ji Yinduo [6060 6892 6995], Hu Xujing [5170 4872 2417], et al., Institute of Epidemiology and Microbiology, Chinese Academy of Preventive Medicine, Beijing]

[FBIS Transcribed Text] To identify the antigenic specificity of meningococcal bactericidal antibodies, the bactericidal antibodies in sera collected from different sources have been detected. The results indicated that the bacterial antibodies Vs.Nm group A were found in the sera of carriers of *N. lactamica*, rabbit immunized with N1 1105, the convalescent sera of cases of epidemic meningitis and the sera of carriers of *N. meningitidis* serogroup A as well as the sera of rabbit immunized with *N. meningitidis* serogroup A. IgG, IgM and IgA purified from the above sera specifically reacted with class 1,2/3 OMP. Moreover, class 1,3 OMPs and LOS purified from N1 1105 were found to induce good immune response to *N. meningitidis* serogroup A in the Kunming strain of white mice. Class 1 OMP could induce IgG, class 3 OMP induced both IgG and IgM, whereas LOS mainly stimulated formation of IgM. In addition, the results demonstrated that class 1,3 OMPs and LOS purified from N1 1105 could inhibit the bactericidal activity of IgG. The comparative inhibitory activity was as follows: LOS > class 1 OMP > class 3 OMP. From the above findings, it is believed that LOS and class 1 OMP of *N. lactamica* seem to be major specific antigens inducing the bactericidal antibodies against meningococci. These results provide important information for raising prophylactic effect of serogroup A meningococcal vaccine to infants.

Key words: *N. lactamica* (NL); *N. meningitidis* (NM); Outer membrane protein; Lipooligosaccharide; Bactericidal antibodies.

Coleopterancidal δ -endotoxin and Constructing Its Genomic Library

40091001F SHENGWU GONGCHENG XUEBAO
[CHINESE JOURNAL OF BIOTECHNOLOGY]
in Chinese Vol 10 No 2, May 94 pp 103-108

[English abstract of article by Li Xiaogang [2621 1420 0474] and Li Rongsen [2621 2837 2773], Wuhan Institute of Virology, Academia Sinica, Wuhan]

[FBIS Transcribed Text] The composition of crystal protein and plasmid patterns, in five new coleopterancidal strains of *Bacillus thuringiensis* were investigated. Larvae of *Plagioderia versicolra* was chosen as model insect in assay of toxicity. Strain YM-03 had the highest toxicity. Plasmid patterns were detected by rapid agarose gel electrophoresis. It was demonstrated that plasmid patterns of five strains were quite different. The partial amino acid sequences for N-terminal of YM-03 crystal protein was analyzed by amino acid analyzer. Genomic library of coleopterancidal δ -endotoxin of YM-03 has been constructed. The EcoRI fragments (20-30kDa) of the total DNA were ligated with vector DNA of pLAFRI. Thirteen clones which contained both pLAFRI and foreign DNA fragments out of 17 recombinant plasmids were obtained. The frequency of recombinant clones was 76%. Three positive clones, named LE392(pBYM2), LE392(pBYM3) and LE392(pBYM4)

were detected from 1200 resistant clones by using a synthesized 18bp probe from a coleopterancidal δ -endotoxin gene. It was demonstrated that LE392(pBYM3) and LE392(pBYM4) have the same EcoRI digestion pattern. They all contained coleopteran specific δ -endotoxin gene but showed a different level of expression.

The Glutamate Biosensor and Its Application to Flow Injection Analysis System

40091001G SHENGWU GONGCHENG XUEBAO
[CHINESE JOURNAL OF BIOTECHNOLOGY]
in Chinese Vol 10 No 2, May 94 pp 109-113

[English abstract of article by Ye Bangce [0673 1620 4595], Li Qingshan [2621 7230 1472], et al., Research Institute of Biochemical Engineering, East China University of Science and Technology, Shanghai]

[FBIS Transcribed Text] An enzyme electrode was prepared by cross-linking the *L*-glutamate oxidase with glutaraldehyde on an aminopropyl-platinized-platinum wire. It was used for the determination of *L*-glutamate in a flow injection analysis system. The peak current is linearly related to the *L*-glutamate concentration in the range 0-2.0 mmol/L, with good performance: accuracy (CV = 0.4%), fast response (<60sec), stability (>20 days).

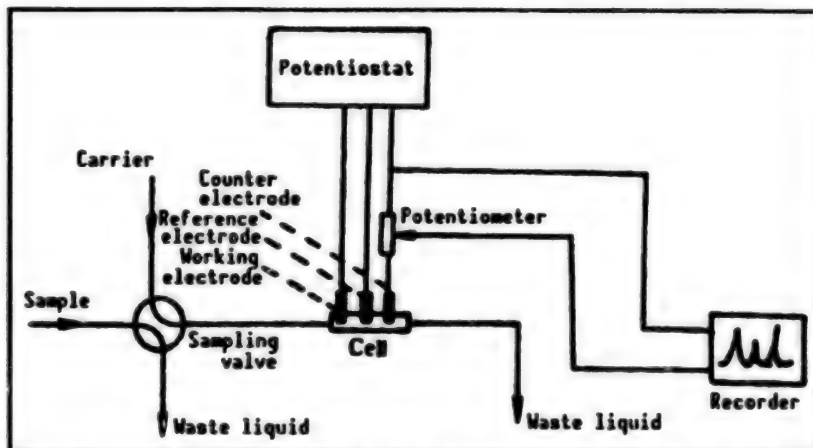


Figure 1. Schematic Diagram of the Flow Injection Analysis System for Glutamate

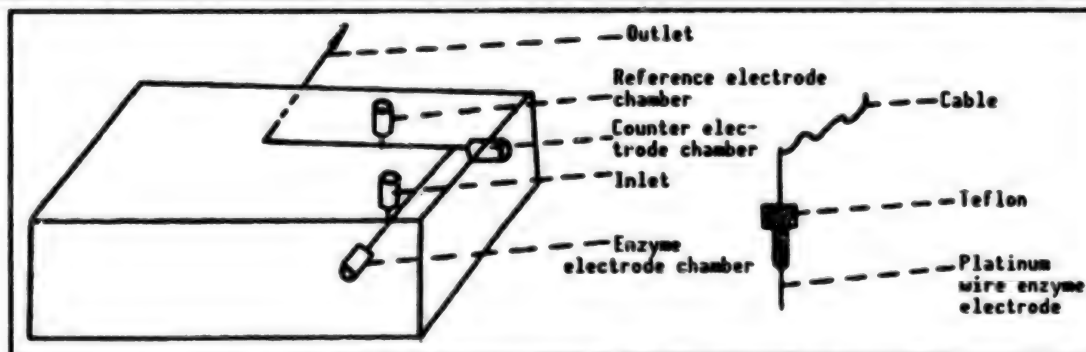


Figure 2. Schematic Diagram of the Flow-Through Cell

Preparation, Characterization and Application of Monoclonal Antibodies Against PAI-1

40091001H SHENGWU GONGCHENG XUEBAO
[CHINESE JOURNAL OF BIOTECHNOLOGY]
in Chinese Vol 10 No 2, May 94 pp 135-141

[English abstract of article by Ding Hao [0002 4110], Wu Xiaoli [0702 2556 0196], et al., Laboratory of Molecular Genetics, Shanghai Medical University, Shanghai]

[FBIS Transcribed Text] Six hybridoma cell lines (AP1, AP2, AP3, AP4, AP5 and AP6) secreting monoclonal antibodies (McAb) against PAI-1 were obtained by fusing the murine myeloma cell line SP2/0 with the spleen cells from BALB/c mouse immunized with recombinant PAI-1 expressed in *E. coli*. These antibodies were purified by SPA affinity chromatography. All McAbs recognized rPAI-1 and PAI-1 from the human hepatoma cell line HepG2. The titers of ascites were more than 10^6 . The antibody-antigen affinity constants (K_{aff}) for anti-PAI-1 McAb measured by ELISA were between 3.45×10^7 - 1.05×10^{10} mol/L. AP2 and AP3 McAbs were quite effective in quenching the activity of PAI-1. Partial quenching of PAI-1 activity was achieved with AP4, AP5 and AP6 McAbs, respectively. AP1 McAb had no effect upon PAI-1 activity. Three of the six McAbs (AP1, AP4 and AP5) bound to the PAI-1/t-PA complex, while the others did not.

The PAI-1 was purified 51 folds to homogeneity from serum free medium of HepG2 with the recovery rate of 92% by one-step procedure using Sepharose 4B conjugated with anti-PAI-1 McAb (AP1, AP3 and AP4). A sandwich ELISA for the measurement of PAI-1 antigen in human plasma was developed based on anti-PAI-1 McAb against non-overlapping epitopes. The mean value of plasma PAI-1 for the healthy donors was 24.7 ± 7.75 ng/ml measured by ELISA.

Molecular Design and Target Sample Preparation for a Prolonged-Acting Insulin

40091001I SHENGWU GONGCHENG XUEBAO
[CHINESE JOURNAL OF BIOTECHNOLOGY]
in Chinese Vol 10 No 2, May 94 pp 142-150

[English abstract of article by Xu Wenqing [6079 2429 3237], Zeng Zonghao [2582 1350 3185], et al., Institute of Biophysics, Academia Sinica, Beijing; This project was funded by UNIDO (91/048) and China high-Tech Program (863-21-01).]

[FBIS Transcribed Text] In order to prepare prolonged-acting insulin derivatives, a principle is proposed as: making some additional non-covalent bonds between monomers and stabilizing the oligomer of insulin so as to cause the protracted action from a depot-effect. Based on the accurate three-dimensional structure, a designed scheme of the mutation B2Val \rightarrow Lys/Arg is rationally suggested. Computer simulation and modelling predicted that this kind of substitution will bring on a prolonged action and keep the substantial biological potency. On the guidance of this analysis, a derivative desB1-LysB2-Insulin is prepared by semisynthesis as a target product. Biological test and biochemical characterization indicate that this target sample really exhibits an evidently prolonged action with a nearly full potency lowering blood glucose in rabbits. The possibility and the problem for the practical use of this sample are also discussed.

Study on Biosensors Based on Jade Plant Tissue

40091001J SHENGWU GONGCHENG XUEBAO
[CHINESE JOURNAL OF BIOTECHNOLOGY]
in Chinese Vol 10 No 2, May 94 pp 151-156

[English abstract of article by Zhuang Yunlong [8369 0061 7893], Department of Chemistry and Chemical Engineering, Shanghai University of Technology, Shanghai]

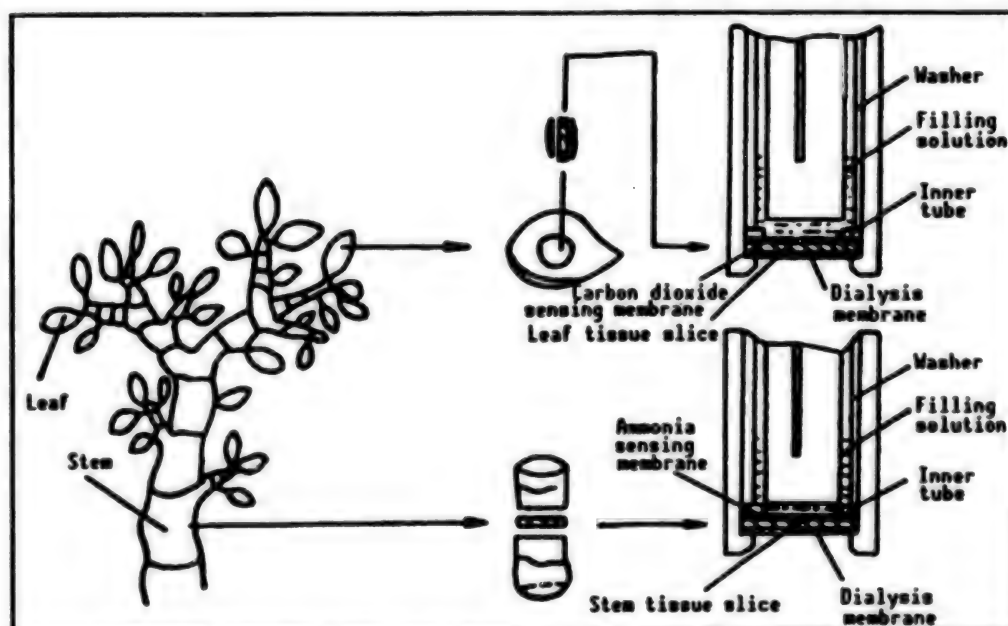


Figure 1. Schematic Diagram of Constructing Jade Plant Tissue-Based Sensors

[FBIS Transcribed Text] Two novel biosensors based on leaf and stem of jade plant as biocatalytic material have been designed and constructed by coupling with potentiometric carbon dioxide gas sensing electrode and ammonia gas sensing electrode respectively. The leaf tissue-based sensor has high selectivity to *L*-arginine, having linear range of 1.0×10^{-4} – 1.0×10^{-3} mol/L, detection limit of 3.2×10^{-5} mol/L and response slope of 42.2 mV/dec. The stem tissue-based sensor with good selective response for *L*-lysine shows linear range of 8.0×10^{-5} – 3.0×10^{-3} mol/L, detection limit of 2.2×10^{-5} mol/L and slope of 41.1 mV/dec.

Expression of Trichosanthin in *Saccharomyces cerevisiae*

40091001K SHENGWU GONGCHENG XUEBAO [CHINESE JOURNAL OF BIOTECHNOLOGY] in Chinese Vol 10 No 2, May 94 pp 173-177

[English abstract of article by Lu Wang [0712 8001 7245], Dang Wei [8093 0251], et al., National Laboratory of Protein Engineering and Plant Genetic Engineering, Peking University, Beijing]

[FBIS Transcribed Text] Trichosanthin is a wide-band anti-viral Chinese herb medicine. Highly-purified trichosanthin has shown potential of preventing HIV infection. The gene coding for trichosanthin, a Chinese herb protein, was fused to the yeast α factor promoter and its leader sequence. The chimeric gene was constructed in the yeast shuttle plasmid pMM and cultured for 24 hours, after transformation of yeast cells with vector. The highest level of trichosanthin expression was detected by anti-trichosanthin antiserum. The expressed trichosanthin was found contained in the cell. This is the first report on expression of trichosanthin in *Saccharomyces cerevisiae* in the world.

Chaperone Molecule GroE Purification and the Refolding of Recombinant Proteins as Facilitated by Chaperones

40091001L Shanghai SHENGWUHUAXUE YU SHENGWUWULI XUEBAO [ACTA BIOCHIMICA et BIOPHYSICA SINICA] in Chinese Vol 26 No 4, Jul 94 pp 365-370

[English abstract of article by Xu Mingbo [1776 2494 3134], Meng Wenhua [1322 2429 5478], et al., Institute of Basic Medical Sciences, Academy of Military Medical Sciences, Beijing]

[FBIS Transcribed Text] Found in recent years, chaperones are a new class of proteins which catalyze protein folding reaction *in vivo*. The GroEL and GroES were purified from *E. coli* with multicopy plasmid of pGroESL, and studied the active state of the molecule and the optimum reaction condition of GroEL and GroES. Results indicate that good catalyzing efficiency can be achieved only with equal molar of GroEL and GroES, and in the presence of 1mM ATP and suitable concentration of K^+ . With the action of chaperones, the correct folding ratio of IL-2 (at 1mg/ml) increased from 30% to 58%, and the specific activities of IL-2 and GM-CSF were more than doubled. Gel filtration

and HPLC result suggests that chaperones can reduce oligomer formation during protein refolding.

Cloning and Expression of the Yeast PHO4 Gene

40091001M Shanghai SHENGWUHUAXUE YU SHENGWUWULI XUEBAO [ACTA BIOCHIMICA et BIOPHYSICA SINICA] in Chinese Vol 26 No 4, Jul 94 pp 383-387

[English abstract of article by Zhao Youyang [6392 0645 7122] and Ao Shizhou [2407 0013 3166], National Laboratory of Molecular Biology, Shanghai Institute of Biochemistry, Academia Sinica]

[FBIS Transcribed Text] Through *in situ* hybridization, two DNA fragments were cloned from *S. cerevisiae* chromosomal DNA. Ligating these two fragments, a 3.4kb intact PHO4 gene was obtained. The coding region of PHO4 gene was replaced with the yeast URA3 gene. This replaced PHO4 gene was used as donor to transform YPH499 to URA3. A *pho4* mutant was resulted from disruption of the chromosomal counterpart. Acid phosphatase (APase) activity in various cells was used to assay the function of PHO4. Unlike the wild type strain, the level of APase activity was repressed under low Pi condition in the *pho4* mutant strain. Transformation of this mutant strain with the intact PHO4 gene reversed the mutant phenotype. PHO4 is a positive regulator in the Pi-repressible acid phosphatase system. The coding region of PHO4 was fused in frame with LacZ and β -galactosidase activity in various cells was determined. The results show that PHO4 expression is Pi-independent and not controlled by itself nor by other protein factors.

Cloning and Modification of *clts857* Gene for Constructing the Regulated Expression Vectors

40091001N Shanghai SHENGWUHUAXUE YU SHENGWUWULI XUEBAO [ACTA BIOCHIMICA et BIOPHYSICA SINICA] in Chinese Vol 26 No 4, Jul 94 pp 389-396

[English abstract of article by Li Boliang [2621 0130 5328] and Jiang Zhihong [3068 1807 4767], Shanghai Institute of Biochemistry, Academia Sinica]

[FBIS Transcribed Text] The modified *clts857* gene of λ phage was obtained by cloning a 990bp DNA (*clindlts857*Sam7), modified by deletion of the 3'-noncoding sequence and mutation of two HindIII sites. It was used to construct expression vectors (pBLMV12 and pBLMFV4, 5B, 6), which have three open reading frames in linker for inserting the DNA fragments without the start codon ATG. Using the above constructed expression vectors, the high-level products, such as Met-Phe-bGH, Ala-bGH, hIFN- γ AC-13 and *pho85* expressed in *E. coli* harboring their expression plasmids induced at 42°C were observed by analysis of SDS-PAGE and dye staining. This suggests that the modified *clts857* gene in the expression plasmids can work well and its expressed protein can regulate the P_L promoter in the same plasmid.

Involvement of Membrane Sialoglycoproteins in Mice Erythrocytes Invaded by *Plasmodium chabaudi*

400910010 Shanghai SHENGWUHUAXUE YU SHENGWUWULI XUEBAO [ACTA BIOCHIMICA et BIOPHYSICA SINICA] in Chinese Vol 26 No 4, Jul 94 pp 427-431

[English abstract of article by Liu Junfan [0491 0193 0416] and Lu Yiqin [4151 5030 2953], Department of Biochemistry, Hunan Medical University, Changsha; and Ronald L. Nagel and Olga O. Blumenfeld, Department of Medicine, Division of Hematology and Department of Biochemistry, respectively, Albert Einstein College of Medicine, New York; This work was supported by Grants No. 5926-1635 and GM 16389 from NIH, Bethesda, Md.]

[FBIS Transcribed Text] The extent of participation and changes of sialoglycoproteins (SGPs) in the merozoite-mice erythrocyte interaction during the invasion of *Plasmodium chabaudi* were studied by immunoblotting techniques. Several bands of lower molecular weights (14.5 to 29 kd) were detected in the *P. chabaudi*-parasitized mice erythrocytes, their saponin lysates and pellets when cross-reacted with anti-human α GP antiserum and antipeptide C (residues 82-131) serum, implying that certain degree of structural homology exists between SGP of mice erythrocytes and α GP but not δ GP of human erythrocytes. Multiple EBA-like antigens with molecular weights less than 30 kd were also recognized in *P. chabaudi*-infected mice erythrocytes, their saponin lysates and pellets when cross-reacted with subtertian malaria hyperimmune serum. These results suggested that an intermingling of disintegrated membrane SGPs with the EBA-like antigens occurs in the mice erythrocytes invaded by *P. chabaudi*.

Processing of Methionine at the N-terminal of Protein Expressed Highly as Inclusion Body in *E. coli*

40091001P Shanghai SHENGWUHUAXUE YU SHENGWUWULI XUEBAO [ACTA BIOCHIMICA et BIOPHYSICA SINICA] in Chinese Vol 26 No 4, Jul 94 pp 433-436

[English abstract of article by Yang Xinying [2799 2450 4481], Liang Zhenhe [2733 6966 0735], et al., Shanghai Institute of Biochemistry, Academia Sinica]

[FBIS Transcribed Text] Two kinds of recombinant bovine growth hormone (bGH) expressed highly as inclusion body in five different *E. coli* hosts were rapidly prepared from the induced bacteria harboring the constructed expression plasmid containing the synthesized gene encoding N-Met-Ala-bGH or N-Met-Phe-bGH. All of the above prepared proteins reached 80% purity as analyzed by SDS-PAGE and N-terminal amino acid sequencing. The results show that the first amino acid is Ala at the N-terminal of protein expressed by the N-Met-Ala-bGH gene and the N-Met are removed with the yield over 90%. However, the highly expressed products encoded by the N-Met-Phe-bGH gene contain N-Met with the yield over 97%. This suggests

that the second amino acid Phe at the N-terminal of proteins may affect the activity of N-Met-specific peptidase.

Cloning and Expression of the Bacteriorhodopsin (BR) Gene

40091001Q Shanghai SHENGWUHUAXUE YU SHENGWUWULI XUEBAO [ACTA BIOCHIMICA et BIOPHYSICA SINICA] in Chinese Vol 26 No 4, Jul 94 pp 447-450

[English abstract of article by Lu Chunlin [4151 2504 2651], Wang Jian [3076 0313], et al., Chien-Shiung Wu Laboratory, Southeast University, Nanjing; and Ye Yin [0673 1377] and Tian Bo [3944 3134], Institute of Microbiology, Academia Sinica, Beijing]

[FBIS Transcribed Text] The first strand of bacteriorhodopsin gene (bop gene) was synthesized by reversely transcribed from the total RNA of *H. halobium* (S9 strain) and amplified to get cDNA by the polymerase chain reaction (PCR). The sequence of PCR amplified product was determined, and the full length of bop gene was shown. The product of bop gene expression in *E. coli* was observed by Western blotting. BR is a 26 kd protein extracted from halophilic bacteria, *Halobacterium halobium*. BR is considered to be an ideal biological material not only for biological membrane, but also for holograph and pattern recognition molecular device research.

Molecular Epidemiological Characteristics of *Salmonella typhi* Strains Isolated in China—1. Analysis of *Salmonella typhi* Strains Isolated in China by Multilocus Enzyme Electrophoresis

40091001R Beijing ZHONGHUA LIUXINGBINGXUE ZAZHI [CHINESE JOURNAL OF EPIDEMIOLOGY] in Chinese Vol 15 No 4, Aug 94 pp 218-222

[English abstract of article by Xu Wenbin [1776 2429 2430], Qi Guoming [4359 0498 2494] and Liu Yanqing [0491 1693 3237], Institute of Epidemiology and Microbiology, Chinese Academy of Preventive Medicine, Beijing]

[FBIS Transcribed Text] Multilocus enzyme analysis by polyacrylamide gel electrophoresis (PAGE) was used to analyze 335 isolates of *S. typhi* from several provinces where high morbidity of typhoid fever was observed in recent years. We analyzed seven metabolic enzymes encoded by chromosome. The results showed that all the enzyme loci were polymorphic. The average alleles per locus was 7.4 (2-19), the mean genetic diversity per locus was 0.498 (0.198-0.883). There were 147 distinctive electrophoretic types (ETs) in 335 isolates. With cluster analysis by the average-linkage method, 22 subclones, 12 clones among all isolates studied were found. Most isolates in 1988 from both Jiangsu and Zhejiang provinces belonged to one clone; the isolates from Guangxi Province in 1990 and parts of Hubei isolates belonged to one clone; the isolates from Hunan and Guizhou provinces during several year period were homogeneous. However, the isolates from Xinjiang Autonomous Region were remarkably different

from other provinces, belonging to a particular clone. The isolates from an outbreak of epidemic were found to be from one subclone.

The Study on ELISA Methods for Detection of Specific Antibodies Against Hemorrhagic Fever With Renal Syndrome Virus in Rat Sera

40091001S Beijing ZHONGHUA LIUXINGBINGXUE ZAZHI [CHINESE JOURNAL OF EPIDEMIOLOGY] in Chinese Vol 15 No 4, Aug 94 pp 227-230

[English abstract of article by Xu Haifeng [1776 3189 1496], Yang Weisong [2799 3634 2646], et al., Department of Infectious Diseases, Tangdu Hospital, Fourth Military Medical University, Xian]

[FBIS Transcribed Text] Three ELISA methods were developed to detect specific antibodies against hemorrhagic fever with renal syndrome virus (HFRSV) in rat sera using monoclonal antibody (McAb) technique. The three McAb-ELISA were tested to be more specific, sensitive, and simple than the indirect fluorescent antibody (IFAT) method for the detection of HFRSV antibodies in rat sera, the detection rate was 88.5 percent. Because of the introduction of anti-rats Kappa light-chain McAb derived from mice into rats, two of the three newly developed methods, the antibody-absorption ELISA and the indirect sandwich ELISA, were found to be useful for early detection of HFRSV in animal vectors such as wild rats and mice used for laboratory experiments.

Minister Hu Qili's Comments on China's NII

95P60021A Beijing ZHONGGUO DIANZI BAO [CHINA ELECTRONICS NEWS] in Chinese 12 Oct 94 p 1

[Article by Wang Xuewu [3769 1331 2976]: "Hasten Development of Information Industry, Information Market to Contribute to the Domestic People's Economic Information Modernization"]

[FBIS Summary] At a symposium on the information market and international cooperation convened in Beijing on 6 October [and concluded on 8 October], Minister of Electronics Industry Hu Qili proposed six measures for implementing China's National Information Infrastructure (NII) policy:

- (1) Strengthen the national will. The State Council will take the lead in promoting national information modernization, and has already established a 20-agency "State Economic Information Modernization Joint Conference," chaired by Vice Premier Zou Jiahua, to direct planning, formulate standards, and organize and coordinate major transregional and transdepartmental systems engineering projects.
- (2) Strengthen national information legislation, especially for technical standards, intellectual property rights (IPR) protection, and telecommunications and information services regulation.
- (3) Expand international cooperation in all areas, including attraction of foreign capital and importation of advanced technologies.
- (4) Promote the unification of technology and trade, to further adjust the structure of the electronics industry. Under market-oriented principles, and based on domestic industrial demand and world trends, the following key information technologies should be stressed: computers, communications, integrated circuits, software, and data bases.
- (5) Encourage entrepreneurial firms to develop and compete in the market.
- (6) Stress technical training in information technologies.

Digital Information Network Launched

40100009A Beijing CHINA DAILY in English
24 Oct 94 p 1

[Article by Gao Jin'an]

[FBIS Transcribed Text] With the inauguration on Saturday of a nationwide digital data network, China is one giant step closer to merging onto the information superhighway.

The network, called CHINADDN, is based on powerful fibre-optic, digital microwave and satellite transmission systems. It now connects 21 municipalities and provincial capitals across the country.

To date, China has constructed 53,000 kilometres of optic cable lines, over 46,000 kilometres of digital microwave lines and a number of satellite earth stations—the keys to the network.

Hao Weimin, a deputy director general of the directorate General of Telecommunications under the Ministry of Posts and Telecommunications, said CHINADDN provides 776 high-speed ports and 2,580 quasi high-speed ports.

He said that the main users of the network will be the securities and banking industries, scientific research institutes, large enterprises and other sectors that rely on large volumes of data communications.

The first group of users includes the Bank of Communications, Bank of Construction, Agricultural Bank of China, State Foreign Exchange Administration, and State Administration of Taxation.

Hao, also a chief engineer, said the ministry will enlarge the network by building a second phase next year to serve more users. It will hook up an additional 300 cities next year.

The network uses the most advanced digital telecommunications technology and equipment in the world, and its opening provides a solid foundation for the construction of the country's information expressway, he said.

Local posts and telecommunications administrations are also building their own DDN networks. To date, 14 provinces and municipalities, including Guangdong, Shanghai, Beijing, Shandong, and Henan, as well as 17 cities, including Harbin, Haikou, Xi'an and Shenzhen, have opened DDN networks.

Hao said that CHINADDN has been connected with digital data networks in a number of countries, including Japan and Italy, via international gateways in Shanghai and Guangzhou.

The public packet switching network, Chinapac, opened last year. In addition, a trunk network for information transmission, which now covers more than 400 cities, has been connected with 44 public packet switching networks in 23 countries and regions, including the United States, Japan, France, Canada, Italy, Germany, South Korea, and Hong Kong.

In the future, all computer networks and information systems will be connected through CHINADDN and Chinapac, forming a public information network with functions including human-to-computer and computer-to-computer communication.

Nationwide Data Network Kicks Off

40100012C Beijing CHINA DAILY in English
8 Nov 94 p 2

[Article by Xiao Pei]

[FBIS Transcribed Text] China's nationwide data network was officially put into use on Sunday.

The National Public Digital Data Network (China DDN) was supplied and installed by the Newbridge Networks Corp of Canada.

Visiting Canadian Prime Minister Jean Chretien and Yang Xianzu, Vice-Minister of Posts and Telecommunications, cut the ribbon and started the network.

DDN, which was built in only two months, is an information transmission backbone in the country, Yang said.

The network now covers Beijing, Tianjin, Shanghai and 18 provincial capitals around the country. The Ministry of Posts and Telecommunications (MPT) will enlarge the network by building a second phase next year to link an additional 300 cities.

Newbridge is negotiating with MPT for the contract to supply equipment for the second phase, company chairman Terence Matthews said.

Entering China about seven years ago, Newbridge has provided more than \$50 million worth of networking products to the country.

Over 40 provinces and cities in the country have introduced Newbridge's networking systems.

China is investing heavily to improve its communications infrastructure, opening a huge market for foreign companies.

Matthews said his company's business in China will grow to about 10 per cent of its total business in a couple of years.

Newbridge will invest in the country to launch some manufacturing plants in coming years, he said.

Founded in 1986, Newbridge is now a world leader in designing, manufacturing, marketing and servicing multi-media, standards-based networking products.

China's First Digital Mobile Telephone Network Completed

40100012A Beijing CHINA DAILY (BUSINESS WEEKLY) in English 31 Oct 94 p 6

[Article by Li Wen]

[FBIS Transcribed Text] Guangzhou—Already at the apex of China's reforms and modernization, Guangdong Province has completed the country's first digital mobile telephone network.

The move spells the end of the analog telecom era in China as the country steadily moves to digital communications.

The provincial-level experimental network, set up last week, covers 28 cities and counties in the booming Pearl River Delta region.

The four exchange bureaux in Guangzhou, Shenzhen, Zhuhai and Huizhou are composed of 53 stations, within which cellular telephones may be used.

Digital cellular phones from Hong Kong, if registered in the network, can also be operational in the South through the services.

Deng Xiaofeng, planning and marketing manager with Guangdong Mobile Communication Co., said the new network has a potentially large market in Guangdong as the dynamic economy requires advanced telecom services.

The new service, recognized by the Group Special Mobile (GSM) Roamer, the European telecom standard, is more reliable, confidential and resistant to interference than the analog service.

And IC-card capability is to be introduced, functional on all the digital mobile phones.

Guangdong Posts & Telecommunications Administrative Bureau, the province's telecom boss, pioneered the open analog mobile phone in 1987, snaring more than 410,000 users by the end of this September.

"Analog capacity is to reach 1 million by the later half of next year," Deng said.

The new network set up last week cost them about \$30 million to complete. Foreign equipment was introduced from Sweden's Ericsson, Germany's Siemens, Italy's Italtel and Canada's Northern Telecom.

Telecom Deal Worth \$200 Million Signed

40100012B Beijing CHINA DAILY in English
8 Nov 94 p 2

[Article by Li Zhuoyan]

[FBIS Transcribed Text] Guangzhou—Canada's leading telecommunications giant signed a three-year deal yesterday to supply Guangdong Province with much-needed high-tech equipment.

Northern Telecom is to sell up to \$200 million worth of products to Guangdong Provincial Posts and Telecommunications (GPTB) and Guangdong Machinery Import and Export Corporation (Machimpex).

"This agreement ensures that Northern Telecom will contribute to making the telecommunications services in Guangdong among the most advanced in the world in the years to come," Nortel China chairman Arthur Macdonald said.

Under the agreement, GPTB and Machimpex will buy DMS Supernode central office telecommunications switches from Northern Telecom's new factory, which will open in Shunde City in 1995.

The joint venture will manufacture DMS products for the domestic and overseas markets.

The new deal calls for the Guangdong firms to also purchase Intelligent Network (IN) equipment and services, Magellan broadband switching systems, Synchronous Digital Hierarchy (SDH) transmission equipment, GSM cellular telephone systems and high-capacity fiber-optic information access systems.

Since 1987, when its first China office opened in Beijing, Northern Telecom has rapidly expanded its business across China. It is working to shift its digital telecom equipment design and production bases to China. It already has production plants in Shenzhen and Nanjing and training and technological service centres in Beijing and Xi'an.

And Northern Telecom is proceeding with its \$130 million investment plan, which it unveiled on 22 April.

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Principle Tests of Reactor-Pumped Laser of ^3He -Ar-Xe System

40100011A Chengdu QIANG JIGUANG YU LIZI SHU
[HIGH POWER LASER AND PARTICLE BEAMS]
in Chinese Vol 6 No 3, Aug 94 pp 325-329

[English abstract of article by Chen Hande, Jin Xingxing, Yang Chengde, Yang Weidong, Li Bing, Hu Zechun, Liu Dongyan, Li Jiansheng, and Ren Xingbi, Southwest Institute of Nuclear Physics and Chemistry, P.O. Box 525-75, Chengdu, 610003; Cai Xijie, Mao Jianhua, and Chang Bin, Shanghai Institute of Optics and Fine Mechanics, CAS, P.O. Box 800-211, 201800; (MS received 7 Jan 93, revised 21 Mar 94)]

[FBIS Transcribed Text] A reactor-pumped laser was demonstrated for the first time by using the $^3\text{He}(\text{p}, \text{n})^3\text{H}$ reaction to excite a ^3He -Ar-Xe laser. Lasing was observed on the $1.73 \mu\text{m}$ ($5\text{d}(3/2)_1 - 6\text{p}(5/2)_2$) transition in Xe I. The CAEP pulsed reactor (CFBR-II) [China fast breeder reactor-II] was used as a source of fast neutrons moderated by a 50-mm thick polyethylene sleeve around the laser cell. A laser cell was constructed from K_9 glass tubing 600mm long and $\phi 34\text{mm}$ with each end cut at the Brewster angle (quartz). The laser cell was baked out to 10^{-3}Pa prior to filling with research-grade mixture ($^3\text{He}/\text{Ar}/\text{Xe}=34.7: 34.7: 0.267 \text{ kPa}$). A dielectric-coated 2-m radius-of-curvature back mirror (99.7% reflectivity at $1.73 \mu\text{m}$) and a flat output coupler ($\phi 30\text{mm}$) were used to form the optical cavity. The cavity optics were placed outside the cell.

A schematic of the experimental configuration is shown in Figure 2. Typical laser signals are obtained with a Ge detector (-80°C). Laser output lags the fast-neutron pulse by the neutron thermalization time ($278 \mu\text{s}$). The observed light output was shown to be caused by stimulated emission, because the signal disappeared when the reflecting (flat) mirror was covered. This precludes the possibility that the phenomenon was the result of γ -radiation interaction with the detector or the air in the

light path. The measured laser energy was 80 times the maximum possible fluorescence energy. The observed wavelength was measured to be $1.73 \mu\text{m}$ by using glass filters. Laser output duration was approximately $735 \mu\text{s}$. [Laser output power for four experiments is shown in Table 3 below; thermal neutron flux is 6×10^{14} neutrons/ cm^2/s .]

Table 3. The Measured Value of Laser Power

	MHAX12	MHAX13	MHAX14	MHAX15
Peak power (MW)	763.9	926.4	783.3	894.1
Signal intensity (mV)	11.9	16.9	2.94*	7.50
Power output (mW)	3.27	4.64	7.50	2.08

*The transmissivity is 40%.

Laser Cell for Reactor-Pumped ^3He -Ar-Xe Lasing Experiments

40100011B Chengdu QIANG JIGUANG YU LIZI SHU
[HIGH POWER LASER AND PARTICLE BEAMS]
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[English abstract of article by Liu Dongyan, Hu Zechun, Jin Xingxing and Zhao Xiaolin, Southwest Institute of Nuclear Physics and Chemistry, P.O. Box 525-75, Chengdu 610003; MS received 4 Jan 94, revised 12 Mar 94]

[FBIS Transcribed Text] The atomic Xenon laser operates at the near infrared at wavelengths 1.7 and $3.6 \mu\text{m}$ predominantly on transitions between 5d and 6p manifolds. The CFBR-II pulsed reactor facility (CAEP) is used to study excitation of atomic Xe laser. The laser cell is placed beside the CFBR-II reactor, surrounded by high-density polyethylene to moderate fast neutrons. According to the structure of polyethylene, the gain in various rare-gas mixtures and the neutron calculations for energy deposition, the $600\text{mm} \times \phi 34\text{mm}$ laser cell is horizontally placed to minimize damage to cell optics by debris or gas decomposition products. In this work, equal amounts of He and Ar and 0.4% Xe were used. The typical He/Ar/Xe mixtures used were 69.7 kPa total pressure, 34.7 kPa He, 34.7 kPa Ar and 26.7 kPa Xe. The laser-cell active pumped volume is $\phi 34\text{mm} \times 600 (\text{mm}^3)$ and is made of K_9 glass tube. The cell has $18\text{mm} \times 30\text{mm}$ quartz windows mounted at the Brewster angle. The cavity optics are placed outside the cell. The cavity mirrors consist of a 2-m radius-of-curvature, concave high reflector, and a flat one. The gas cell can be evacuated to less than 10^{-3}Pa and be filled with research-grade He/Ar/Xe mixtures by the vacuum system that we produced. The vacuum system includes a mechanical pump, two manometers, a molecular sieve column, an active carbon column and a diffusion pump.

In this work, we produced the laser cell and used it in the first test of reactor-pumped ^3He -Ar-Xe ($\lambda = 1.733 \mu\text{m}$) successful lasing.

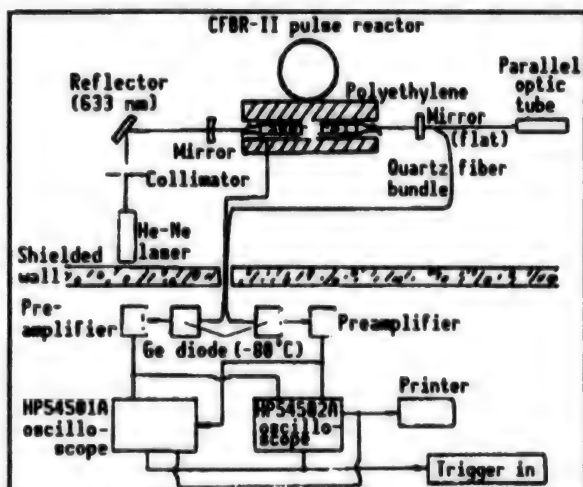


Figure 2. Schematic of the Experimental Configuration

Free Electron Laser Amplifier Experiments on SG-1

40100011C Chengdu QIANG JIGUANG YU LIZI SHU
[HIGH POWER LASER AND PARTICLE BEAMS]
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[English abstract of article by Hui Zhongxi, Zhou Chuanming, Wu Ruian, Deng Jianjun, Chen Yutao, Ding Bonan, Tang Longzhou, Zhang Jun, Meng Fanbao, and Tao Zuchong, China Academy of Engineering Physics (CAEP), P.O. Box 517, Chengdu; and Yang Zhunhua, Tian Shihong, Dong Zhiwei, and Wu Shangqing, Beijing Institute of Applied Physics and Computational Mathematics, P.O. Box 8009, Beijing 100088; MS received 20 Nov 93, revised 28 Jan 94]

[FBIS Transcribed Text] The SG-1 FEL facility is composed of a linear induction accelerator (LIA), an electron-beam transport system, a wiggler, a microwave source and a diagnostic system. SG-1 LIA provides a 2 kA, 3.0-MeV beam with a normalized emittance of 0.4-0.6 (π rad-cm), an energy spread (FWHM) of 4%, resulting in a beam brightness of nearly 10^8 A/(π m-rad)². The beam current through the wiggler is about 600 A. The 4m-long linearly polarized wiggler consists of specially shaped solenoids with an 11-cm period. The electromagnetic wiggler can provide a peak magnetic field on-axis of 0.24-3.2T, continuously variable. Each two periods of the wiggler are energized by a separate power supply, which allows variation of the strength and longitudinal profile of the wiggler magnetic field. Vertical and horizontal focusing of the electron beam in the interaction region is provided by the natural focusing of the parabolic pole face wiggler. The microwave input signal to the amplifier is provided by a 34.6 GHz, 20 kW magnetron. Through a separator, this signal is injected into the waveguide taper, converted from the TE₁₀ mode to the TE₀₁ mode of the oversized FEL waveguide (2.9 cm x 9.8 cm). Then it is injected into the interaction region through the coupler. After passing the dielectric window at the end of the main waveguide, the amplified signal is sent directly to variable attenuators so that the signal can be reduced to a level at which it can be measured by traditional crystal detectors. The output signal is measured in the far field.

The first ASE experiments began in September 1991. We utilized a 2.6m-long wiggler with a peak magnetic field of 0.3T. At 35.8-36.5 GHz, an ASE output of 0.5 W was obtained for a beam current of nearly 50 A. After a shutdown of about 8 months, the second series of ASE experiments began in October 1992. According to the first ASE experimental results, the numerical simulations and the measured beam quality, we believed that the quality of the beam was good enough to substitute a 2m-long drifting and focusing system for the 9m-long beamline. Meanwhile, we increased the length of the wiggler from 2.6m to 4m. The second series of ASE

experiments was performed with a wiggler magnetic field between 0.25 and 0.27T. The maximum output power is about 100 kW for $B_w = 0.24$ T, $I = 600$ A, at $\nu = 35.2$ GHz.

Based on the ASE experiments, we carried out the amplifier experiments on SG-1. Using a 300 W input signal (TE₀₁), a beam current of about 600 A and wiggler magnetic fields of 0.24-0.28T, we measured the FEL output power as a function of the wiggler magnetic field. The resonant magnetic field was about 0.25T. Meanwhile, in order to study the amplifier gain, we measured the FEL output power as a function of the wiggler length at a peak wiggler magnetic field of 0.26T. We can easily find out that the exponential gain is approximately 19 dB/m and the maximum output power is about 10 MW.

Initial Analysis of Amplifier Experiments on SG-1 FEL

40100011D Chengdu QIANG JIGUANG YU LIZI SHU
[HIGH POWER LASER AND PARTICLE BEAMS]
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[English abstract of article by Meng Fanbao, Wu Ruian, Tang Longzhou, Zhou Chuanming, and Hui Zhongxi, Southwest Institute of Electronic Engineering, CAEP, P.O. Box 523-66, Chengdu, 610003; MS received 9 Jul 93, revised 22 Mar 94]

[FBIS Transcribed Text] The experiments on SG-1 FEL with the 0.26T wiggler magnetic field and 4m-long wiggler have generated a peak microwave power of 100 kW in the small-signal mode, about 10 MW and 19 dB/m gain at 34 GHz in the amplifier mode using a 3.3 \pm 0.15 MeV, 600 A electron beam. The amplifier gain curves (microwave power as a function of wiggler magnetic field) and the amplifier performance show the good FEL principle and are in agreement with the numerical simulations. But there has been no saturation and the starting point of the exponential gain portion of the curve is delayed to 1.5m. The main reason is that the quality of the electron beam is not so good and the input microwave power through the wiggler is low.

Recently, the SG-1 FEL group has been improving some units of the SG-1 FEL for the next experiment, according to the situation of SG-1 FEL. It is quite important to enhance the quality of the electron beam through the wiggler. The new electron beam transport will be used for the next experiment in order to enhance the quality of the electron beam and the FEL's performance. Experiments will then proceed with high-power microwave generation and high-current beam. This will permit an investigation of the tapered wiggler operation.

The SG-1 FEL's microwave output is monitored with the calibrated crystal detectors. It is necessary to study how to calibrate the crystal detectors. In particular, the calibration of the crystal detectors operated at repetition rate is different from that in the narrow pulse mode.

SG-1 FEL Amplifier Output Power Reaches 140 MW

95P60013A Chengdu QIANG JIGUANG YU LIZI SHU
in Chinese Vol 6 No 3, Aug 94 p back cover

[Article by Zhou Chuanming [0719 0278 2494] "China's Free Electron Laser Amplifier Output Power Surpasses 100MW Level"]

[FBIS Summary] At its SG-1FEL facility CAEP successfully conducted an FEL amplifier high-power calibration experiment on 1 September 1994: at a radiative frequency of 34.4 GHz, output power reached 140 MW. With an LIA providing a 3.3-MeV, 800-A electron beam, a saturated power of 51 MW was obtained with a 2.42-m-long wiggler. With variations in wiggler parameters and techniques, output power was raised to the 140 MW level, the highest output power for such an FEL so far realized in Asia.

Advances in Synthesis of, Research on New Nuclides in China

94FE0565A Beijing ZHONGGUO KEXUE YUAN
YUANKAN [BULLETIN OF THE CHINESE ACADEMY
OF SCIENCES] in Chinese Vol 9 No 1, Feb 94 pp 22-27

[Article by Wei Baowen [7614 1405 2429], Luo Yixiao [5012 0076 1321], and Jin Gengming [7246 2704 2494], Institute of Modern Physics]

[FBIS Translated Text]

Abstract

The significance of the synthesis of and research on new nuclides away from the line of stability is discussed. The physical concept, technical approach and breakthroughs made in the synthesis of and research on neutron-rich nuclides away from the line of stability in China in the past two years are described using the first successful synthesis of ^{208}Hg , ^{185}Hf and ^{237}Th as examples. The direction of new nuclide synthesis and research in the rest of the century and in early next century is discussed and recommendation for the construction of major facilities is presented.

[Introduction]

The past two years have been two quite exciting years for nuclear physicists in China. Three new heavy-mass neutron-rich nuclides, i.e., ^{202}Pt (Shanghai Institute of Nuclear Research), ^{208}Hg and ^{185}Hf (Institute of Modern Physics), were successfully synthesized in China in 1992. Another new nuclide, ^{237}Th , was synthesized in 1993. In addition, a new delayed β low-energy α decay path for ^{20}Na was discovered. This process plays a significant role in nuclear astrophysics. This paper describes the significance and experimental results of the work done at the Institute of Modern Physics in Lanzhou on the synthesis and study of new heavy-mass neutron-rich nuclides.

1. Significance of Synthesis of and Research on New Nuclides Away From the Stability Line

The synthesis of new nuclides away from the β stability line and the study of their decay characteristics, nuclear structures and formation mechanisms is one of the leading edge

research in nuclear physics and nuclear chemistry, particularly in heavy-mass ion physics. In this highly competitive field of basic research, various laboratories in the world are investing a great deal of resources and manpower to build a large number of advanced instrumentation and equipment. China invested 150 million yuan to build a heavy-mass ion accelerator together with all the necessary instruments and equipment at the CAS Institute of Modern Physics in order provide the experimental tool for our researchers to compete in this field.

An atomic nucleus is comprised of protons (Z) and neutrons (N). Different nuclei are called nuclides. In addition to proton number Z and neutron number N, the sum of the two, i.e., $A = Z + N$, is also used as an important parameter to describe a nuclide. More than 300 stable and long-lived radioactive nuclides exist in nature. In a Z vs. N plot, stable nuclides are concentrated along a narrow region. The curve that passes the center of that region is the β line of stability. Theoretical nucleus structure models (such as shell model, liquid drop model, collective model, etc.) were mostly established based on studies done on nuclides near the line of stability. However, as nuclear physics advances and technology in accelerator and nuclear detection moves to higher levels, more nuclides were produced by way of nuclear reactions, i.e., they expand along both Z and N axes in the Z-N plot. People noticed that neutron rich or neutron poor nuclides that are far away from the line of stability, especially those near or on the neutron drop line (i.e., the line connecting the series of last nuclides with zero neutron binding energy in the Z-N plot) and those near or on the proton drop line (i.e., the line connecting the series of last nuclides with zero proton binding energy in the Z-N plot), have very unique characteristics such as abrupt increase of nucleus radius, extreme distortion, abnormal stability and strange decay processes (e.g., emission of one or more neutrons after a β decay, emission of one or more protons after a β decay, direct emission of protons, or spontaneous emission of complex particles heavier than carbon). These effects attracted the interest of nuclear physicists. A wide range of studies were launched to investigate whether existing theoretical nuclear models still apply to those nuclides and important progress has been made. People have recognized that the synthesis of more new nuclides, especially those far away from the line of stability, will play a significant role in the study of their decay characteristics and nuclide structures and in the validation and development of existing theories. In addition, the synthesis of and research on new nuclides will be a positive driving force to push the frontier of astrophysics and atomic physics forward. The study of the synthesis mechanism of new nuclides will also promote the development of nuclear physics and nuclear chemistry as well and will potential benefits in energy and military related research activities.

Artificially synthesized nuclides are usually obtained by way of a nuclear reaction. A certain nuclide is accelerated by an accelerator to bombard another nuclide. A new nuclide is formed by way of a properly selected reaction. Normally, the new nuclide is produced in minute quantity, sometimes less than one one-millionth of the nuclides produced by the nuclear reaction. It must be separated

from a large number of known nuclide before a new nuclide can be identified and studied. Since the discovery of artificial radioactivity in 1934, 2,100 nuclides have been synthesized and identified so far. To date, the following methods are primarily used to synthesize nuclides.

- light particle induced reaction (n , p , d , α);
- heavy-mass ion fusion evaporation reaction (including cold fusion);
- fission;
- fragmentation of medium-energy projectile nuclide;
- spallation caused by high-energy proton.

To verify whether a new nuclide is created, a variety of separation techniques, such as chemical separation, on-line isotope separation, etc., are used. These techniques require large-scale equipment and instrumentation, such as isotope separator, ion velocity selector, recoil mass spectrometer, fragment isotope separator, liquid chromatograph, and gas chromatograph.

To date, there are approximately 600 artificially synthesized nuclides that can be synthesized in theory and separated and verified in practice. Most of them are neutron rich. However, the probability of success becomes smaller and the lifetime gets shorter as unknown nuclides stay farther away from the line of stability. It becomes more difficult to separate and identify. To synthesize these 600 nuclides, it is necessary to seek for suitable reaction mechanisms and systems and to establish special separation and identification methods. Hence, the synthesis of new nuclides not only has important academic values but also will push the technology forward.

On the basis of theoretical considerations, due to nuclide structure effect, there are a number of nuclides in the heavy-mass neutron-rich zone (proton number $A > 170$) far away from the line of stability. Their half lives are much longer than those known nuclides in the vicinity. For example, the theoretical half life of ^{208}Hg is 2,900-29,000 seconds. This is much longer than the half life of ^{206}Hg , which is known to be 490 seconds. The theoretical half life of ^{202}Pt is several dozen hours, which is also much longer than the 12.5-hour, half life of ^{200}Pt . If such nuclides can be synthesized, it will play a critical role in the validation and development of nuclide structure theory. Researchers at our institute predict that there is an island of β^- delayed neutron decay precursor nuclides near proton number 82 and neutron number 126. These nuclides all decay by emitting β^- delayed neutron. The only β^- delayed neutron emitting nuclide discovered so far in the region is ^{210}Tl . It is of great physical significance to confirm the presence of such an island of β^- delayed neutron emitting nuclides in the heavy-mass neutron-rich zone.

Nevertheless, the synthesis of new nuclides in this mass region progressed very slowly in the past due to difficulties encountered in developing reaction mechanism and separation and identification techniques. The methods described earlier are almost ineffective in synthesizing neutron-rich nuclides in the heavy-mass region. It is an intriguing topic to seek for a new reaction mechanism to synthesize heavy-mass neutron-rich nuclides. In addition,

separation of heavy elements is also a major topic for more in-depth research. Although an on-line isotope separator can separate nuclides of different masses and other electromagnetic separation methods can separate all reactants "in flight," due to various reasons such as extreme low-recoil kinetic energy, it is impossible to achieve recoiled flight. Furthermore, high-melting-point elements cannot undergo thermal diffusion from the target ion source, which limits the separation techniques described earlier. Therefore, new separation and identification techniques must be developed to meet the need in the synthesis and identification of neutron-rich nuclides in this mass region.

The synthesis, separation and identification of nuclides in the heavy-mass neutron-rich region pose a serious challenge to the physics community worldwide. They also present us with an opportunity. In order to make breakthroughs in physical concept and technical approach in this difficult field, we chose to focus our effort in the synthesis of new nuclides in the heavy-mass neutron-rich region and are working very hard to remain in a competitive position in the world.

II. Synthesis and Identification of ^{208}Hg

This project was completed on the Lanzhou heavy-mass ion accelerator by Zhang Li [1728 4539], et al., of the nuclide synthesis and research team. We chose to synthesize ^{208}Hg by a multiple of nuclear conversion reactions involving bombarding a ^{208}Pb nucleus with projectiles. The probability of such reactions is very low. Especially when using heavy ions with a "cluster structure" such as ^{12}C to bombard the target, the probability is even lower. To this end, two special measures were taken to increase the production of ^{208}Hg . One is to raise the energy of the injection beam so that it travels a longer range in the target. Next, a thick target was used to stop the injected beam in the target. Specifically, 360 MeV ^{12}C ions were used to bombard a lead target.

To release, separate and identify the ^{208}Hg produced, a special experimental apparatus was built. The apparatus is comprised of a target melting furnace and a thermal chromatography column which is connected to the furnace. The lead target is melted in this apparatus to allow all the low-melting-point elements to evaporate. These evaporated elements are carried to the cold-end of the thermal chromatography column by pure helium gas. As they pass the thermal chromatography column, they precipitate at various spots according to their melting points. The lowest-melting-point element is located closer to the cold end of the column. On the basis of this principle with a special mercury absorber, this apparatus is extremely selective to mercury and has a very high collection efficiency. Our experimental results showed that elements in the vicinity of mercury, such as lead, bismuth and thallium, could not reach the cold end of the thermal chromatography column and the method has a mercury collection efficiency of over 90 percent. This apparatus was used to gather the mercury produced in the ion-beam-bombarded lead target in the synthesis of ^{208}Hg . Since the chemical selectivity of the apparatus is very high, the mercury specimen collected does not contain bismuth and thallium.

Because ^{208}Hg decays radioactive by emitting β^- to become ^{208}Tl , if ^{208}Tl could be found in the mercury specimen gathered, then it proves that ^{208}Hg is produced in the reaction. The mercury specimen is then purified again and then a special chemical separation method (cow method) is employed to extract thallium from the specimen at a fixed time. Furthermore, it is placed in a low background laboratory to measure the energy and half life of its characteristic γ ray with a γ detector. Experimentally, a γ emission line identical in energy and half life to the strongest γ line of ^{208}Tl at 2614.6 keV was observed. This γ emission is obviously due ^{208}Tl decay. Hence, it is confirmed that ^{208}Hg was produced. On the basis of the intensity variation of ^{208}Tl at different times, the half life of ^{208}Hg was calculated to be 42 minutes. In addition, from the intensity of ^{208}Hg obtained, it was estimated that its mean production cross section in the 60-360 MeV region is 10 microbar.

Although the ^{208}Hg half life obtained, i.e., 42 minutes, is only close to the lower limit of theoretical prediction, it is much longer than that of ^{206}Hg (i.e., 8.15 minutes). This experiment is a verification of the theoretically predicted value. It also indicates that the nuclide structure has an obvious effect on its decay characteristics.

III. Identification of Neutron-Rich ^{185}Hf

The synthesis of this new nuclide was done by Yuan Shaunggui [5913 7175 6311], et al., with a high-power neutron beam at Lanzhou University and the Institute of Modern Physics. Using neutrons to induce various reactions to synthesize nuclides has been used for decades. Can new nuclides still be synthesized using this method? Our analysis shows that this is still a feasible approach. A limited number of nuclides can still be synthesized in the heavy-mass neutron-rich region. ^{185}Hf is such an example. ^{185}Hf was synthesized by bombarding natural tungsten with a 14-MeV neutron beam from a strong neutron source equipped with a high-voltage doubler. The reaction involved is $n + ^{186}\text{W} \rightarrow ^{185}\text{Hf} + 2p$ (two protons). Of course, the probability of this reaction is very low. To raise the amount of the nuclide produced, approximately 20 g of target material is used in every experiment and it is irradiated at an intensity of 1×10^{12} neutrons/s or more. A special chemical process is employed to rapidly separate Hf from tungsten for γ analysis.

There are two ways to identify a radioactive nuclide by measuring its decay pattern. One is to directly measure its radiation and then determine the identity of the nuclide on the basis of its energy, intensity, and half life. The other is to measure the radiation released as a result of the decay of its daughter nucleus to determine the identity of the daughter nucleus and then identify the parent nuclide itself. For a new radioactive nuclide, since the energy, intensity, and half life of the radiation it emits are unknown, the first method is obviously not practical. We identified ^{185}Hf by way of its daughter, ^{185}Ta .

Two γ lines, i.e., 177.56 keV and 107.80 keV, were measured from the Hf specimen. On the basis of energy levels, relative intensity, and half lives of the two γ lines, we knew they came from ^{185}Ta . Because the intensity at 177.56 keV is stronger, its variation was measured as a function of

time. It was found that its intensity obviously went through different formation and decay stages. This is a unique phenomenon associated with parent/daughter decay. On this basis, it was determined that ^{185}Hf was produced in the reaction and ^{185}Ta was a result of its decay. The half life of ^{185}Hf was determined to be 3.5 minutes by matching its intensity variation with a theoretical model. This is very close to the half life predicted by theory. In addition, a new γ line (164.5 keV) was found. Based on its energy and half life, it was determined that this is a decay path for the neutron-rich ^{185}Hf . The formation and decay pattern of ^{185}Ta and the new 164.5-keV γ line are sufficient proof that ^{185}Hf exists. Its formation cross section is approximately 20 microbar.

IV. Synthesis and Identification of ^{237}Th

As discussed earlier, the synthesis and study of heavy-mass neutron-rich nuclides with $A > 170$ if of significance academically; moreover, they are very difficult to accomplish. It is especially difficult to synthesize neutron-rich nuclides such as ^{237}Th . One of the difficulties is that in the reaction to form ^{237}Th , product nuclei are extremely susceptible to fragmentation, yielding medium-mass nuclides. The probability to produce heavy nuclides is extremely low, in the vicinity of one one-millionth. The second difficulty is that the nuclide has an extremely short life. It is extremely challenging to effectively separate Th from a large amount of fission products in a very short period of time for identification.

Researchers at the Institute of Modern Physics once again employed the 14-MeV fast neutrons produced by a high-voltage doubler neutron source at the institute to bombard trinitroureanilamide to produce ^{237}Th . In order to improve yield, more than 60 runs were attempted and a 1500-gram target was used. The researchers worked long and hard to design a fast chemical separation process. After more than a year of repeated testing, it was finally possible to effectively and rapidly separate Th from a large number of complex reaction products. Furthermore, interference of Sb and I isotopes to the major characteristic γ rays (i.e., 853.5 keV and 865.5 keV) of ^{237}Th was successfully eliminated. A large amount of data not only proved that ^{237}Th was synthesized but also determined its half life to be 5 minutes.

This accomplishment fills a void in the synthesis and study of heavy-mass neutron-rich nuclide with $A > 170$. It also demonstrated the intelligence of Chinese researchers and their capability to perform major basic research. A unique concept and technical approach has been established, which will have some impact on this competitive field worldwide.

V. Discovery and Study of Delayed β Low-Energy α Decay of ^{20}Na

^{20}Na is on the major path between the hot CNO chain and the Na, Mg, Al chain. It is a key nucleus to form cosmic elements. It plays an important role in nuclear astrophysics. Theoretically, it is predicted that it has a strong delayed β and low-energy α decay. However, experimentally only a weak delayed β low-energy α decay branch was found. Moreover, this data was used to calculate the probability of

transition from the hot CNO chain to the Na, Mg, Al chain in the cosmic-element-forming process. Researchers at the Institute of Modern Physics employed the 35-MeV proton beam generated by the linear proton accelerator at the Institute of High Energy Physics to bombard Ne gas to produce ^{20}Na . A home-made helium jet transport device was used to deliver the ^{20}Na produced to a $(\Delta E(7\mu)+E)$ rotary measurement system to measure particles emitted by the delayed β low-energy α decay of ^{20}Na . A careful analysis of the energy spectrum of charged particles revealed that the branching ratio of the delayed β 0.70-MeV α decay is 3.7 percent; far greater than the 0.5 percent estimate obtained earlier. Hence, the decay network for ^{20}Na is modified.

The discovery of this new α decay path for ^{20}Na also alters the decay of its other excited states. Originally, it was believed that all the 0.70-MeV line in the ^{20}Na delayed β induced α spectrum comes from protons emitted by the 3.046-MeV excited state of ^{20}Na . On this basis, the nuclear reaction rate of the heavenly body was calculated. Our discovery changed the branching ratio of the decay from ^{20}Mg to the 3.046-MeV excited state of ^{20}Na . It provides an important piece of data for the study of the (r,p) process in astrophysics.

VI. Synthesis and Study of New Nuclides Away From the Line of Stability

On the basis of the status and trend of nuclide synthesis and research, the following areas will be the focal points in the near future with the development of radioactive secondary beam facilities and on-line separators.

1. Synthesis of new nuclides, including the synthesis of heavy-mass neutron-rich nuclides and the study of delayed β neutron forerunner nuclides in the vicinity of $Z = 82$ and $N = 126$; synthesis and study of light-mass singular nuclei, particularly drop-line nuclei, (important in astrophysics; synthesis and study of neutron-poor nuclides in the region beyond uranium; and synthesis and study of double-image nuclei with N-Z, such as ^{100}Sn .
2. Study of the strange decay characteristics, nuclear structure and nuclear mass of nuclides far away from the line of stability, including delayed β induced double-proton emission and the yet-to-be-observed direct double-proton emission, which is predicted in theory; study of bound-state β decay; study of neutron halo and neutron skin associated with light neutron-rich drop line nuclides; and study of pure neutron materials.
3. Exploration of the synthesis of ultra-heavy elements.

For many years, nuclides away from the line of stability were synthesized with a stable nucleus. In order to synthesize nuclides near the proton and neutron drop line in the heavy-mass region, it is necessary to use a radioactive nucleus to bombard a proton-rich or neutron-rich target. Hence, the development and radioactive secondary beam devices and the use of such beams away from the line of stability have become the focus of research in all major

laboratories around the world. The first-generation secondary beam comes from fragmented products by medium-to-high-energy projectiles. The second-generation secondary beam is generated by an ion source in a thick target bombarded by a medium-energy beam. It is separated on-line and then accelerated to provide a high-power radioactive beam.

In order to accomplish our objectives in the synthesis and research of new nuclides, and to meet the needs of the rapidly developing heavy-ion physics, it is of great urgency for us to present a plan to develop heavy-ion accelerators in China. A review of the development trend of all heavy-ion physics laboratories around the world shows that, in addition to moving toward higher energy or even the relativistic region, there are two critical areas for heavy-ion accelerators: One is the production, acceleration and accumulation of radioactive nuclides. For many years, accelerators have been used to accelerate stable nuclei as projectiles to conduct experiments. Production and use of radioactive nuclei have moved nuclear physics into a new era. The other is the construction of heavy-ion cooled storage rings to provide high-quality beams (with high energy and position resolution). The storage ring is cooled to lower the temperature of the accelerated ions in order to obtain an ion beam with extremely small deviation in energy and position to substantially improve the accuracy of measurement. A storage ring stores this high-quality beam in a closed loop so that it can be accumulated and used many times to substantially improve the sensitivity of the experiment. Presently, many laboratories around the world are either planning to build or in the process of constructing radioactive nuclear accelerators or heavy-ion cooled storage rings.

After careful research and repeated verification, the CAS Institute of Modern Physics recently replaced the HIRFL-CSR (Heavy-Ion-Reactor Facility at Lanzhou—Cooled Storage Ring) plan, which is a combination of a radioactive nuclear accelerator with a cooled storage ring. The recommended storage ring has a circumference of 141 meters. It is a multi-functional ring that can cool, accelerate and accumulate heavy ions (including radioactive heavy ions and completely naked heavy ions stripped of all outer electrons). The two accelerators presently at HIRFL will be used as injectors and heavy ions will be accelerated to a range of 600 MeV to 1200 MeV by a synchrotron. Beam current in the ring will be accumulated by multi-loop injection and radio-frequency accumulation. Advanced techniques such as electron cooling and random cooling will be used to improve the velocity and position resolution of the heavy ions in the ring.

The construction of such a heavy-ion cooled storage ring not only can replace conventional stable nuclear beams with radioactive beams, but also allows the beam to be recycled for many times. This creates very favorable conditions for the synthesis and study of new nuclides, especially ultra-heavy nuclides. It will also result in a large number of scientific accomplishments in heavy-ion physics research, such as the study of highly charged heavy ions; high-temperature, high-pressure nuclear materials; and the use of heavy ion for cancer treatment. In addition, it will

also stimulate rapid development in ultrahigh-vacuum technology, RF accumulation technology and electron cooling technology.

Wei Baowen was born in November 1935 in Yu County, Henan. He graduated from the Department of Physics at Beijing University in 1957. He is the director of the Lanzhou Branch of the CAS, director of the CAS Institute of Modern Physics, research fellow and director of the National Lanzhou Heavy-Ion Accelerator Laboratory, board member of the Chinese Particle Accelerator Society and chairman of the Gansu Society of Physics. He is an expert with outstanding contributions. In 1980-1989, he was personally involved in the construction of HIRFL. He is directing "new nuclide synthesis and research," a major basic science project in the Eighth 5-Year Plan.

Chinese Scientists Succeed in Synthesizing Ruthenium-90

946B0151A Beijing KEJI-RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 12 Jul 94 p 2

[Article by Li Zhurun [2621 4554 3387] and Han Zhenjun [7281 2182 6511]]

[FBIS Translated Text] Chinese scientists Zhou Zhuhua [0719 2579 5478], et al., succeeded in synthesizing ruthenium-90 for the first time in China. This research result was certified by a ministerial level experts committee consisting of five members of the Chinese Academy, including Wang Ganchang [3769 3227 2490]. The committee considered this achievement another example of successful collaboration between the China Institute of Atomic Energy and the Accelerator Laboratory; it is regarded as an important contribution to China's pursuit in scientific research.

Records show that there are more than 270 stable nuclides in nature. Scientists in the world have synthesized more than 2,400 nuclides. In 1991, a research group led by Zhou Shuhua in the China Institute for Atomic Energy bombarded a nickel-58 target on the III-13 tandem accelerator in Beijing with 115 MeV Chlorine-35 ions. Through a series of experiments and observations, the synthesis of the new nuclide ruthenium-90 (Ru-90) was verified. Its two gamma

decay spectral lines were identified and its half-life measured. The experimental results were included in the authoritative "Tables of Nuclear Data" compiled by the National Welfare Data Center of the Brookhaven National Laboratory.

This result was the only data entry under ruthenium-90. Experts told reporters that the synthesis of Ru-90 was very significant for nuclear space physics and nuclear structural research.

Scientists Discover New Nuclide: Iridium-99

946B0151C Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 9 Jul 94 p 1

[Article by Fan Li [5400 0500] and Hu Lin [5170 7207]]

[FBIS Translated Text] It was disclosed by the Chinese Institute of Atomic Energy today that Chinese scientists discovered a new nuclide: iridium-99. Evaluation by authoritative experts showed that this research result is more innovative than other similar work and that the achievement is of the world class.

The synthesis of nuclides away from the beta-stability line is a frontier research topic in today's nuclear physics field; there has not been too much results in the world. Back in 1985, Zhao Kui [6392 5525] and her research group in the Institute of Atomic Energy began research in this area. Through careful estimation and verification, they formulated a complete experimental plan and, step by step, prepared for the experiments. From 1991 to 1992, while Zhao was a visiting scholar in the United Kingdom, she proposed her experimental plan to the British science and technology engineering committee. The British were highly interested in her plan and provided her with active support. After her proposal was approved, she led the experiments at the Daresbury National Laboratory. With close collaboration of Chinese and foreign scientists at the Laboratory, she discovered the new nuclide iridium-99 and accurately measured its mass. This represented the first time in the world that new nuclide was discovered by the strangeness transfer reaction and the mass measurement method was extended to the $A \approx 200$ region. It provided a new path for synthesizing heavy enriched neutrons.

Overview of Development of Renewable Energy and Rural Energy Construction

946B0124A Chongqing XIN NENGYUAN [NEW ENERGY SOURCES] in Chinese Vol 16 No 6, 5 Jun 94 pp 1-8

[Article by Deng Ke Yun [6772 0668 5686], Office of Environmental Protection and Energy, Ministry of Agriculture; manuscript received 7 Feb 94]

[FBIS Translated Text]

Abstract

This is an update of the status of developing methane gas, coal conservation technology, firewood, small-scale hydropower, solar energy, wind power, and geothermal energy in rural China. The environmental benefit as a result of more efficient use of energy is discussed. The status of rural energy construction as a whole is also reported.

1. Development of Rural Economy Depends Upon Various Energy Sources

In recent years, energy demands in rural China not only increased in quantity but also in quality. In 1992, the total energy consumed is equivalent to 570 million tons of standard coal. Commercial energy sources, such as coal, oil, and electricity (including small-scale hydropower), amounted to 333 million tons of standard coal. Compared to 1980, this corresponds to a 2.3-fold increase. Other renewable energy sources, such as firewood, methane, solar energy, wind power, and geothermal energy, amounted to 237 million tons of standard coal. This corresponds to an increase of 24 percent compared to 1980.

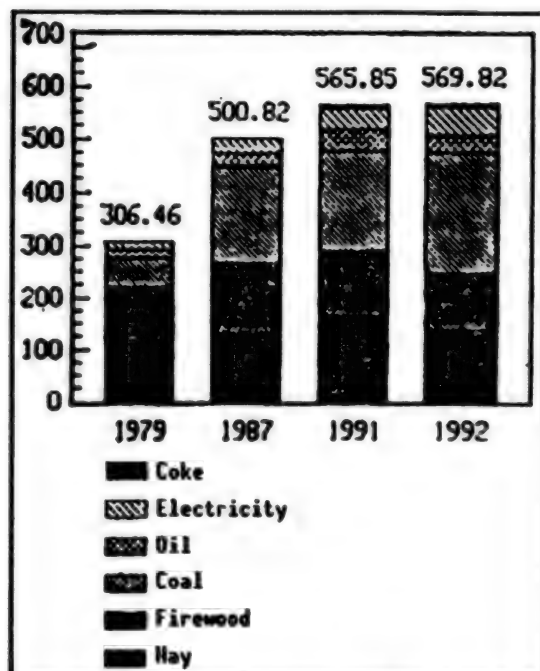


Figure 1. Rural Energy Consumption Structure in China (Unit: million tons of standard coal)

In 1992, the total product value generated by China's rural businesses reached 1,161.1 billion yuan, corresponding to 63 percent of the total product produced by all rural communities and 24 percent of the GNP. In 1990, rural businesses accounted for 72 percent of the clothing, 45 percent of the handicraft, 27 percent of the chemicals, 24 percent of the silk, 28 percent of the light industry products and 22 percent of the textile exported to other countries. In 1992, a total investment of 10.5 billion yuan was made to use industry to subsidize agriculture. This development consumed more than 200 million tons of standard coal of commercial energy sources.

In the past 10 years China's rural energy consumption increased at an annual rate of 10 percent, primarily due to growth of rural industries. However, during the same period, China's commercial energy production only increased at approximately 5.3 percent per year. The production (and supply) of commercial energy cannot steadily and reliably guarantee the availability of energy to meet the demand of a growing rural economy.

There are two solutions. One is to scientifically manage commercial energy sources to conserve energy. Major rural energy consumers (such as brick makers, smelting plants, paper mills and machine makers) must make modifications to conserve energy. The other is to create more sources by using new technology to produce renewable energy sources locally (such as generating electricity with methane, gasification of hay, wind power, solar heating, and recycling of industrial waste) to obtain more clean, high quality energy. This is the policy of both conservation and creation.

In 1993, the government officially set the policy to encourage the utilization of a variety of local energy sources and to encourage energy conservation. Energy development and conservation are treated equally in weight. Furthermore, conservation of coal and firewood, construction of methane pit and development of firewood forest and small-scale hydropower stations were officially listed in the national economic guidance plan. In the Sixth and Seventh 5-Year Plans, development of rural renewable energy sources was included in key technical projects which resulted in the rapid growth of renewable energy sources in China (see Figure 2).

2. Development and Utilization of Renewable Energy Resulted in Increased Farm Production, Forest Coverage, and Improved Rural Life

2.1 Methane utilization serves high-volume, high-qualified, high-efficiency rural industries

Production of methane in rural China is more than a supplemental fuel for cooking. It is a high-quality cooking fuel, as well as an industrial fuel which generates profits for the economy. In 1992, 4.98 million rural households had methane pits installed. There are more than 200 large and medium size methane-environmental protection facilities and 16,000 urban waste purification methane ponds. Approximately 800 million rural households are generating methane and related byproducts with human and animal

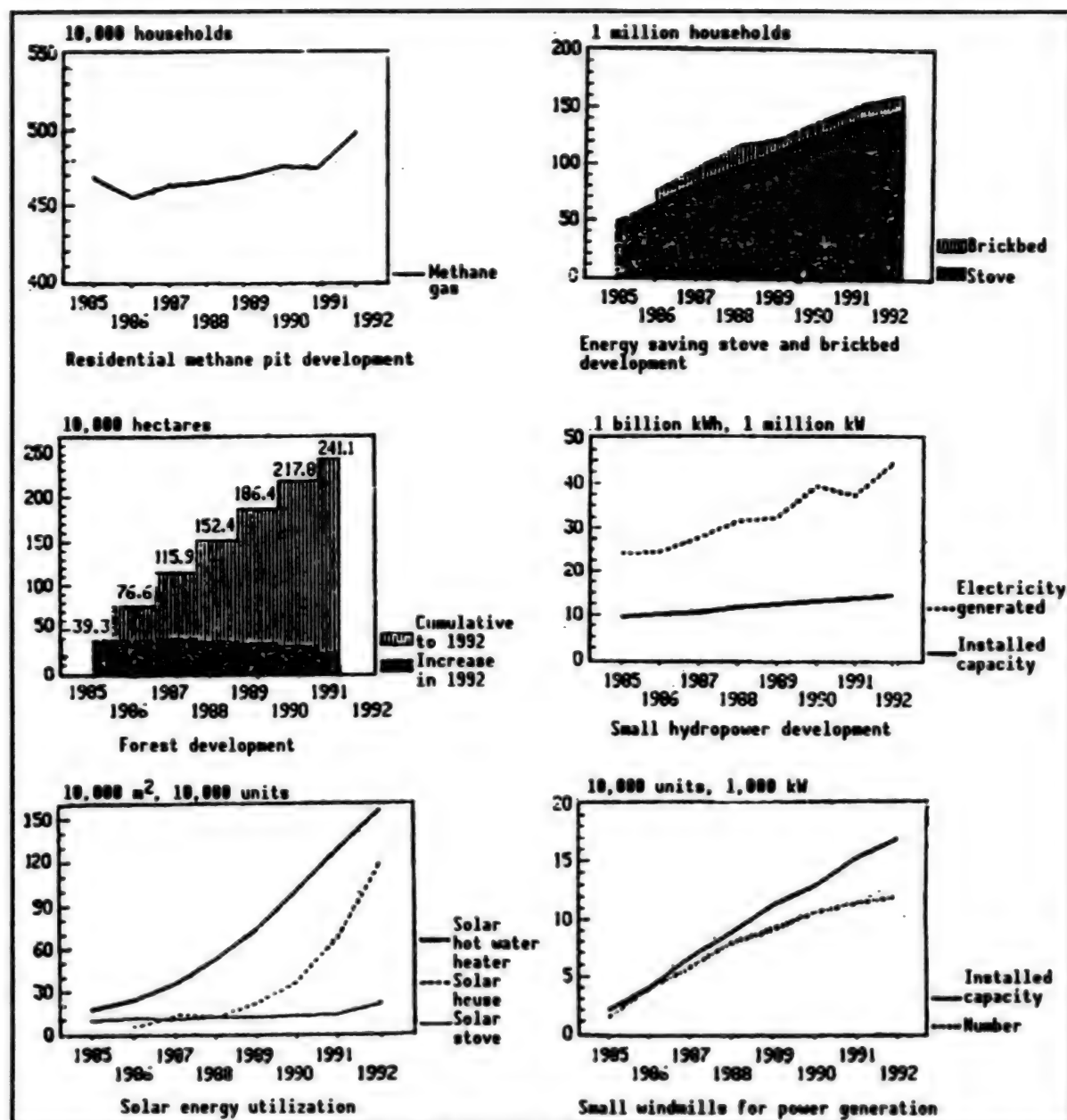


Figure 2. Status of Renewable Energy Development in China

wastes and other organic industrial wastes. Such liquid and solid byproducts are used in certain processes in agriculture to significantly improve the yield.

2.1.1 Soaking seeds in liquid byproduct

The liquid byproduct contains nitrogen, ammonia and organic acid and has a disinfecting effect. Soaked seeds are disinfected which increases their resistance to different diseases. The liquid contains a variety of vitamins, especially different activators which can activate the enzymes in

the seed to enhance its vitality. They make it more likely to sprout. In 1992, 13,600 tons of seeds were soaked and crop yield increased on the average of 10 percent per mu. In 1993, 11,000 tons of seeds were soaked in Hubei, Jiangxi, and Sichuan alone.

2.1.2 Application of liquid and solid byproducts to fruit trees

The liquid byproduct was sprayed on the leaves of Fuji apple trees and the solid was used as a fertilizer in Xixia

County, Shandong, to bump up the yield. This also increased the water and sugar content of the fruit. Apples are being exported annually at very favorable prices. Both liquid and solid byproducts of methane pits are being used in orange groves along the Chang Jiang to produce more fruit. This makes the oranges more resistant to disease and cold weather, and also gives orange growers more incentive to build methane pits.

2.1.3 Using methane to store grain and preserve freshness

Farmers in Hubei and Sichuan periodically deliver a fixed amount of methane gas to the grain storage facility in order to block off the oxygen supply to kill mice and insects. Compared to refrigeration, freshness preservation of oranges by methane costs much less. It can reduce loss by 70 percent.

2.1.4 Four-way combination of methane pit, solar energy pig pen, toilet and vegetable green house

More than 20,000 rural households in Liaoning are using this system to produce methane gas, raise pigs, and grow vegetables in the winter. Fresh vegetables and pork are available on New Year's Day and during the Chinese New Year holidays. The revenue generated by each rural household has risen by 60 percent. The province has ordered its rural energy office to establish an "Energy and Backyard Economy Service Corporation."

2.1.5 Large and medium methane and environmental protection facilities to stabilize gas supply

There were over 200 medium-to-large size methane and environmental protection facilities in China in 1992 that supplied gas to 70,000 households year-round. Progress has been made at several dozen facilities in terms of high efficiency, low cost and multiple purpose use. They are the focus around the world. Not only is their organic waste water treated efficiently, but also hundreds of employees and residents near the plants have gas to use year-round. It really enhances the value of fish and rice farming and tea leaf processing; and it creates a benign ecological cycle for large and medium size farms and enhances their profits.

Farms that employ methane gas technology provide society with high-quality agricultural, animal, fish, forestry, and fruit products and also improve the quality of their local environments. Furthermore, because of higher quality, productivity and efficiency, it brings more income to the farmer (investor). For instance, after 5,000 rural households in Zhujiang County, Hubei, began to utilize methane in a comprehensive manner in 1991, each household increased its earnings by an extra 500 yuan per year.

This type of multi-level recycling economic entity which is widely distributed in Sichuan, Hubei, Hunan, Jiangxi, Liaoning, Shandong, Shanghai, Zhejiang, Fujian, and the first-phase red soil rebuilding zone is an economic entity that can be developed in a sustained manner in rural China.

2.2 Conservation technology to save firewood and coal has alleviated shortage of energy needed for cooking and is directly responsible for increased forest coverage rate in China.

Straw was the primary cooking fuel for peasants in China a decade ago. More than 75 percent of the straw produced was consumed for that application, creating a serious shortage of animal feed and organic fertilizer. In 1981, the government promoted the use of energy conserving stoves in rural areas. It changed the past approach to seek thermal efficiency alone and began to stress conservation, practicality, and convenience. After a decade of hard work, it rapidly took control of the serious situation in which excessive amounts of biomass energy was burned. By 1992, 130 million rural households had stoves that were more than 25 percent thermal efficient. Approximately one-half to one-third of the energy can be saved compared to conventional stoves. Today, energy-efficient stoves are becoming multi-functional commercial products. It is a major rural energy-related industry.

In recent years, "biomass coal," a product developed from straw, has become available in Hebei, Jiangsu, Shandong, Shaanxi, and Anhui as a direct substitute for coal for use in boilers. Moreover, it can be further treated to become "biomass coke," for smelting plants or for export. By doing so, the value of straw per mu can be increased by 40 to 50 yuan.

2.3 Firewood is still the major fuel for cooking, heating, and agricultural byproducts in mountain areas.

In the past decade, out of 100 or so domestic and 80 foreign species of trees for firewood, we selected a number of high-quality firewood trees for different geographic areas in China. We broke away from traditional planting methods and adopted a dense planting pattern and an ultra-short wheel-cutting method. It produces two- to three-times better biomass quality than conventional methods. In addition, some trees can also produce fragrant oil, protein, and tannin extract. This yields several times higher product value than planting for firewood alone. The area covered by forest rose from 50 million mu in the early 1980s to 90 million mu.

The use of energy-efficient stoves in rural China, the modification of heating methods in the north, the improvement and commercialization of tea ovens, and the development of small hydropower stations and methane gas have substantially reduced the demand for firewood and protected young forests. Timber used to be the industry in Suining County in Hunan. Because it used wood as fuel for cooking and industrial processing, it became a "forest deficit" county in the early 1980s. The amount planted could not catch up with that harvested. There began a serious push for energy-efficient stoves in 1985 and worked on developing small hydropower stations. In less than four years, its forestry resource reached a balance. In recent years, there has been a "surplus" every year. In 1992, 13.8 percent of the soil was covered by forest. There is no doubt that this is related to the use of energy-efficient stoves and development of various renewable energy sources.

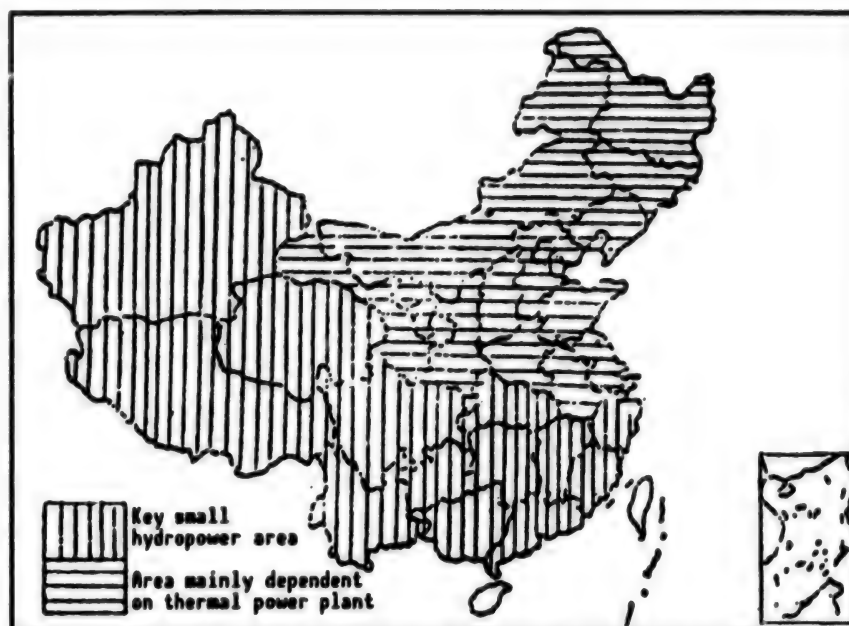


Figure 3. Distribution of Small Hydropower Resource in China

2.4 Small-scale hydropower is a pillar of rural energy. It provided one-third of the total rural electricity demand in 1992.

A small hydropower station is a station with less than 25,000 kW installed capacity. The total amount to be developed nationally is 71 million kW and 20 percent of it was developed as of 1992. Total installed capacity was 14.42 million kW and the amount of electricity generated was 44.2 billion kWh. Figure 3 shows the distribution of small-scale hydropower plants in China.

Small-scale hydropower is the only commercially developed renewable energy source in China. The technology and equipment is not only exported to developing countries but also to developed nations such as the United States. To encourage small hydropower stations, the government took the attitude that whoever builds it also manages it and benefits from it. The major portion of the investment must come from the entity and may be supplemented with government support. "Preliminary electrification" was realized in over 300 counties (over 200 kWh of usage per capita and 200 kWh of residential usage per household). Presently, more than 770 counties rely on small hydropower stations to supply the bulk of their electricity and 21 million rural households use electricity for cooking. The government is working hard to eliminate all "nonelectrified" counties (a total of 32) and to provide electricity to the 200 million people who have no access to electricity by the year 2000. In recent years, micro-hydropower has been promoted in rural areas to meet the needs of rural households scattered over the vast mountain regions. Installed capacity ranges from a few hundred watts to 10 kW and only requires a drop of 1 to 3 meters. The cost of machinery and power transmission is not expensive. As of the end of

1992, a total of 210,000 kW of capacity had been installed. There are approximately 50,000 units in operation, supplying power to 590,000 rural households and generating 124 million kWh of electricity annually.

2.5 Solar energy is abundant in China and the opportunity for development is very promising.

Solar energy will be a hot engineering topic in the next century. It is the "clean energy" of the future.

The use of photovoltaic technology is limited to remote ranches scattered on the prairie, weather stations on mountains or in the ocean, navigation lights and power for illumination, and television sets for ranchers on the move. The total capacity in 1992 was 220,000 W_p. Approximately one-half of that was in Inner Mongolia, and the rest in Xinjiang, Gansu, and Xizang. The solar thermal power plant is still in the laboratory stage. The most widely used solar technology is in direct solar heating, such as the solar stove, ground covering, greenhouses, solar heated barns, passive solar heating houses, and solar heating hot water heaters.

The solar stove was developed early in China, and there are now 130,000 units in operation. They are concentrated in Gansu, Xizang, and Hebei where firewood is in severe shortage. Xizang began to implement the "sunshine" project in 1990 and the solar stove is the most effective item. In 1992, there were 17,000 households in Lhasa and Xigaze using solar stoves. (The government was responsible for technical training and the stoves were purchased by end users.) This has substantially alleviated the energy shortage for residential use.

Considerable progress has been made in solar water heaters, simple solar energy housing, and solar-heated

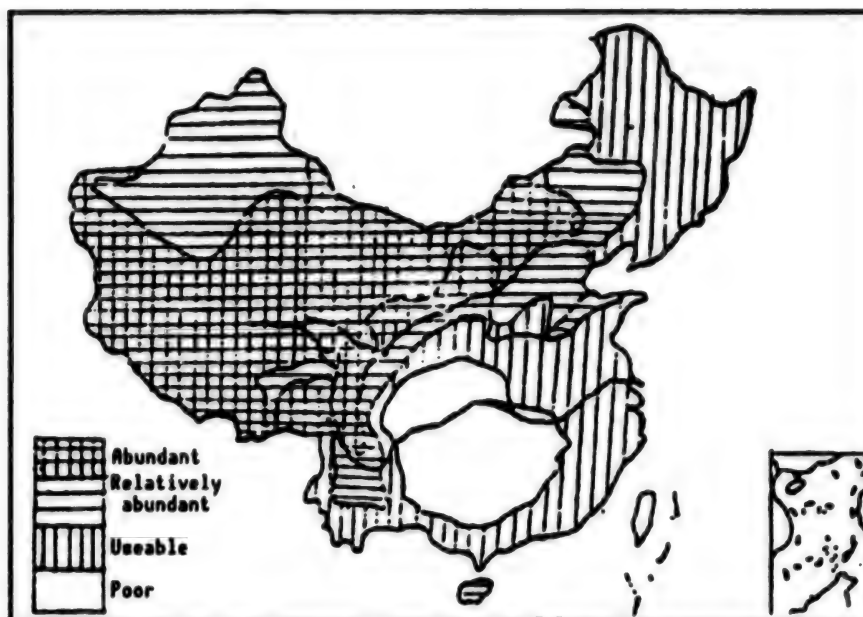


Figure 4. Distribution of Solar Energy Resources in China

elementary and secondary schools since the late 1980s. By 1992, there were 1.56 million m^2 of rural solar hot water heaters. Their use is growing rapidly in Liaoning, Hebei, Shandong, Beijing, Tianjin, Sichuan, and Yunnan.

There were 1.18 million m^2 of solar-heated housing in 1992. It is growing at a rapid pace—approximately 100,000-150,000 m^2 annually; in 1992 alone, the increase

was 500,000 m^2 . It is most used in Liaoning, Jilin, Heilongjiang, Hebei, Shandong, Gansu, and Qinghai. After insulating the foundation and walls of simple solar heating houses in Liaoning, there is no need for auxiliary heating in the winter for the indoor temperature to reach 10°C, 20°C higher than the outside. Nevertheless, the cost per square meter is only 15-18 percent higher than that of conventional design, and therefore, it is well received by the

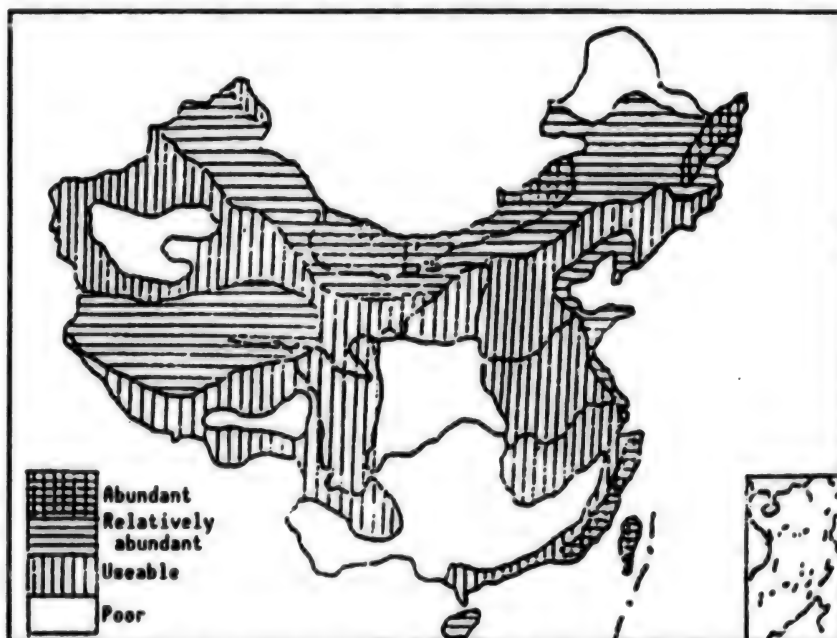


Figure 5. Distribution of Wind Energy Resources in China

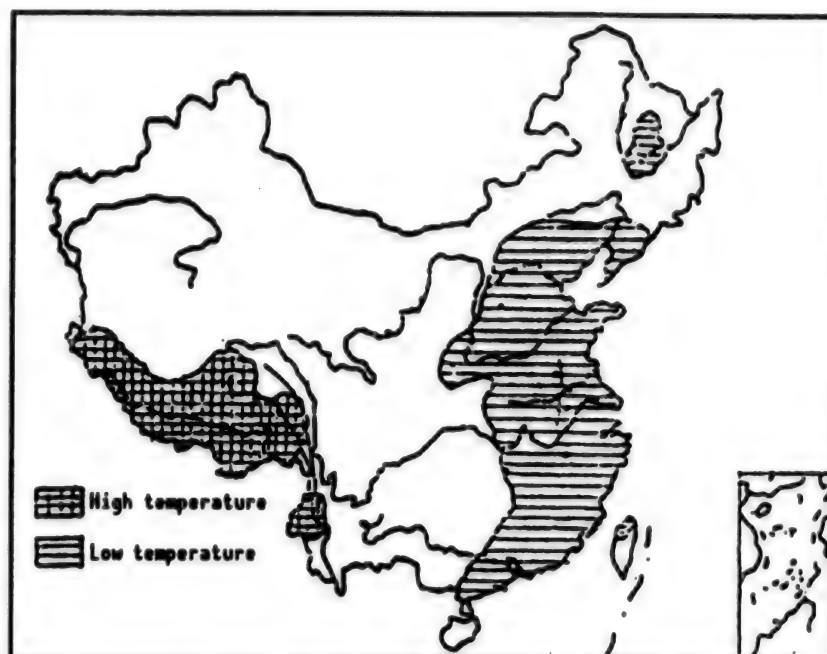


Figure 6. Distribution of Geothermal Resources in China

farmers. In 1991, the State Education Commission and the Ministry of Agriculture held a meeting to exchange solar housing experience in Liaoning and requested solar housing technology be used in renovating school buildings in the 14 provinces and cities. Qinan County in Hebei completed 37 solar-heated school buildings, a total of 42,000 m² in area, with good results.

2.6 Wind energy has a long history in China and modern wind technology is advancing rapidly.

China has medium to low level wind power resources (see Figure 5). There are only a few sites suitable for medium to large size (over 50 kW) windmill power plants. Most places are only suited for small-scale windmills. In 1992, there were 110,000 units of 100 W windmills with a total installed capacity of 17,000 kW which generated 795 kWh of electricity annually. They are located primarily along the coast in Shandong, Zhejiang, and Fujian, as well as in Henan, Gansu, Ningxia, and Xinjiang. The energy is stored by batteries for lighting, television sets, and radios. There are approximately 1,500 wind-powered water pumps in Hebei and Jiangsu. They serve 20,000 mu of farmland for the purposes of irrigation and desalination.

2.7 Geothermal energy is gradually receiving attention.

China's geothermal energy sources are primarily located in Xizang, Yunnan, and along its east coast (see Figure 6); 130-180°C geothermal sources located in Xizang and Yunnan are suitable for power generation and wood drying. One-third of the electric power for the city of Lhasa comes from the Yangbajin geothermal power plant. The development and utilization of the geothermal resource at Tern-chong is being planned. Ninety percent of the geothermal

resources are between 20-60°C. They are suitable for farming, soil heating, seed development, and egg hatching. In 1992, there were 700 geothermal sites being utilized, which is approximately one-third of the total number discovered. There were 1,400 and 930 hectares of land using geothermal energy for farming and breeding, respectively.

3. Improvement of Utilization Efficiency for Commercial and Renewable Energy Creates a Better Environment.

The amounts of energy consumed by the rural industry, aqua culture, agriculture, and animal husbandry to produce 10,000 yuan of product in 1990 have decreased by 44.2, 36.2, 26.8, and 36.5 percent, respectively, compared to those in 1985. Energy saving furnaces in China produced 90 billion bricks. Energy-saving tea ovens produced 300,000 tons of tea. A total of 2.5 million tons of standard coal were saved and the quality of the products was raised one to two notches. It not only saves energy but also raises income.

The development and utilization of rural renewable energy not only saves commercial energy but also improves the environment. More than 100 million rural households are using energy conserving stoves with a thermal efficiency of better than 25 percent. This is a saving of more than one-third of coal and firewood and a one-third reduction of CO₂ and particulate release. Fuyang County in Zhejiang has a very effective rural energy program. The improvement in atmospheric quality is believed to be related to the development of rural energy. In 1987, its mean SO₂, NO_x, and TSP (total suspended particles) levels were 0.071,

0.025, and 0.304 mg/m³, respectively. It was slightly polluted. By 1989, they dropped to 0.055, 0.020, and 0.216 mg/m³ and the air was considered to be clean.

A firewood forest can reduce the capacity of the soil by 6 percent, intercept 98 percent of the runoff, block 99 percent of the sand and dirt, and reduce wind-blown loss of top soil by 70 percent. It plays an important role in improving the quality of stored water and in managing soil erosion.

Treatment of organic anaerobic wastewater not only can enhance the efficiency of organic removal with minimal power consumption, but can also recover methane and other materials. The quality of treated water with oxygenation can meet discharge standards. Furthermore, it consumes 70 percent less power than that of an aerobic project and it also saves land use.

Sichuan has 2 million methane pits that treat nearly 3 million tons of waste produced by 10 million people and 8 million animals annually. They produce 600 million m³ of methane gas and several hundred tons of quality organic fertilizer; 12,000 urban waste purifying methane pits have been built to serve 1.2 million people in 140 counties. They treat approximately 2.7 million tons of waste and the quality of treated water is meeting the discharge standards. Forty-seven large methane pond/environmental protection projects have been built to process more than 30 million tons of high concentration industrial waste water daily to improve water quality and to provide fuel. There are 12 methane/environmental protection facilities along both banks of the Tuo Jiang in Nanjiang to process 650,000 tons of waste from wineries, and 70,000 tons of waste from slaughterhouses annually. It is a demonstration site for environmental treatment in China.

4. Comprehensive Rural Energy Construction by Each County Is an Effective Way to Coordinated Growth of Rural Economy and Environmental Quality.

The concept of constructing comprehensive rural energy sources by county is proposed on the basis of practical experience in the 1980s and the development trend in the 1990s. By relying on the administrative and legislative power of the county, it is hopeful that each county can scientifically plan for its own energy and energy conservation technology on the basis of its own needs to balance economic growth and ecological concerns so that local energy sources can be developed and commercial energy can be utilized more efficiently. Ultimately, a highly coordinated energy supply and demand system can be established. A network of energy industries and technical services can be developed to simultaneously support economic growth and improve rural living conditions from the energy perspective.

Between 1983-1990, 18 counties including Tongliang (Sichuan), Yongchun (Fujian), Wuhua (Guangdong), Kezuo (Liaoning), Nanxian (Hunan), Shucheng (Anhui), Xiji (Ningxia Autonomous Region), and Fuyang (Zhejiang), were selected for comprehensive rural energy construction. In the Seventh 5-Year Plan, 12 county level test sites accomplished the following:

- (1) A 27 percent increase in energy developing capability, an energy saving capacity of 870,000 tons of standard coal, and an improvement of 25.7 percent in effective use of energy for everyday use were achieved. They are all above the national averages.

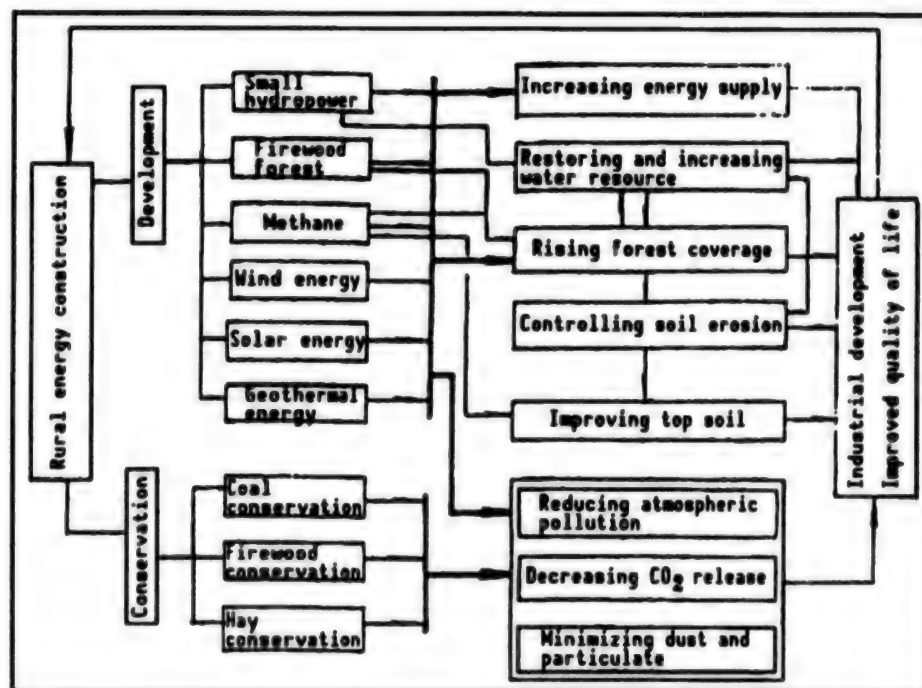


Figure 7. Rural Energy Construction Benefit Diagram

- (2) Soil erosion was treated for 267,000 mu of land, approximately one-third of the area that ought to be treated. The area covered by forest was increased by an average of 6 percent.
- (3) The product to investment ratio for energy construction is 1:5 (with a dividend of 10 percent). The cost of construction for energy production and energy conservation during its life cycle is 32 yuan per ton of standard coal, which is far lower than the national average.
- (4) The shortage of energy for daily use was drastically alleviated. It raised the consciousness in energy conservation and rational utilization, a process that made the rural society more civilized.

Therefore, the ecological and environmental benefit, economic benefit, and social benefit are apparent (see Figure 7).

This 18 county rural energy construction project is the largest scientific study of its kind in China. It received a first place award from the Ministry of Agriculture for technical advancement in 1992. A comprehensive method to develop rural energy has been summarized. Approaches tried and experience gained from this project could be used to guide rural energy construction in similar areas to coordinate the growth of rural economy without adversely affecting the environment. The energy industry bureau of the World Bank, in collaboration with the Ministry of Agriculture, provided funding to conduct studies in this area. APEC officials held three meetings in China on this subject and invited people from over 20 countries to learn the Chinese experience so that other developing nations can try this approach.

Since 1991, the State Planning Commission, Ministry of Agriculture, Ministry of Treasury, Ministry of Water Conservation, Ministry of Forestry, and Ministry of Energy (now Ministry of Electric Power) have jointly organized the development of rural energy sources in over 100 counties to put China's rural energy construction on the right track in order to push it into a new phase. This is one of the projects in the Eighth 5-Year Plan. There are 161 counties undergoing rural energy construction in the Eighth 5-Year Plan.

References

1. Edited by the Ministry of Agriculture, China Agriculture Statistics, Agriculture Publishing Co., November 1992.
2. Deng Keyun, "A Path for Rural Energy Construction in China," *NONGYE GONGCHENG XUEBAO [CHINESE JOURNAL OF AGRICULTURAL ENGINEERING]*, Vol 3, 1992.
3. Environmental Protection Office of the Ministry of Agriculture, Rural Energy Construction Statistics, Internal Release Only, 1992.
4. Abstract of the National Meeting on Comprehensive Use of Methane, November 1992.
5. Qiu Daxiong [6726 1129 3574], editor, Planning and Implementation of Comprehensive Rural Energy Construction, Beijing, Qinghua University Press, December 1991.
6. Li Changsheng [2661 7022 3932], "Treatment and Utilization of Pig Farm Wastewater," Summary of data collected by the national mechanized pig farming society, 1989.
7. Gao Shangbin [7559 1424 2430] and Ma Wenyan [7456 2429 0337], Forest Energy Study, Beijing, China Science and Technology Publishing Co., December 1991.
8. Shi Deming [2457 1795 6900], Yongchun County Field Observation Report, Tracking of 18 County Rural Energy Construction between 1983-1990, June 1993 (internal data).
9. Wang Gehua [3769 7245 5478], Bai Jiruning [4101 6855 2494], et al., Analysis of Rural Energy Construction between 1985 and 1992, April 1993, (internal data).
10. Brown, L., et al., "Save the Earth," Beijing, Science and Technology Publishing Co., April 1993.

Equal Emphasis on Expansion, Conservation in Power Industry Development Urged

946B0155B Beijing ZHONGGUO NENGYUAN [ENERGY OF CHINA] in Chinese No 7, 25 Jul 94 pp 5-8

[Article by Li Renjun [2621 0086 0193] and Lu Gengshan [7627 1649 1472], State Planning Commission: "Equal Emphasis Must be Laid on Expansion and Conservation in the Development of Electric Power"]

[FBIS Translated Text]

1. Since reform and opening to the outside were instituted, the development of China's electric power industry has progressed by leaps and bounds.

The annual increase in installed generating capacity rose from a few million kilowatts to a level of 14.8 million kW in 1993, and the amount of generating capacity built and commissioned every year now equals the amount commissioned in a five-year plan in the past. The annual output of electric energy increased from 256.6 billion kWh in 1978 to 815 billion kWh in 1993, representing an annual increase of 8 percent. The nationwide urban and rural domestic use of electricity increased from 10.5 billion kWh in 1980 to 63.3 billion kWh in 1992, representing an annual rate of increase of 16 percent. Such rapid rates of expansion are virtually unparalleled anywhere in the world. But nonetheless, many parts of the country, including the capital, still experience power shutoffs or cutbacks. This indicates that the expansion of the electric power industry is still not keeping pace with the demands of economic and social development. How must the electric power industry develop in order to meet the needs of economic expansion and social development? In order to quickly put an end to power shutoffs and cutbacks, governments have been drafting

highly ambitious electric power development plans. For example, Shanghai City estimates that in the eight years from 1993 to 2000, it will need to increase its installed generating capacity by 8 million kW, at a total investment of 40 billion yuan. Shenzhen City plans to increase its generating capacity to 5.2 million kW by the year 2000 by adding 4.1 million kW of capacity, which will require an investment of 24.6 billion yuan. For a city or a region to raise such large sums solely for electric power development is not too difficult, given China's policy of reform and opening to the outside, its immense market potential, and its excellent investment environment, but close scrutiny should be given to the question of repayment. By their essence, investments require repayment. The gain that the investor hopes to realize from his investment must be paid. If the return on investment is low, it will be impossible to attract investors. The repayment of all of these investments ultimately is borne by the consumers of electricity. The government departments are only the organizers of power industry construction and are unable to take on the responsibility of repaying the investments. The power plants and power industry corporations are enterprises and proprietors, and it is they that are responsible for paying back the principal and interest on loans.

As the pace of power industry expansion accelerates, electricity prices are rising steadily. The price of electricity for residential users in Shenzhen is 0.5 yuan per kWh. The average price for industrial users is 0.8 yuan per kWh and the terminal cost is 0.7 to 0.8 yuan per kWh; the average price for commercial customers is 0.7 yuan per kWh, with a terminal cost of 0.6 to 1.0 yuan per kWh. In 1994, electricity prices in Shanghai underwent a rather large adjustment. The price charged to non-residential users increased by 0.135 yuan to 0.485 yuan per kWh. These price levels are already equal to or greater than those charged in the United States, and the above adjustments do not include the effect of tax reform. The current rise in prices are not the end of the line. As the cost of building power plants rises, as the annual number of operating hours of the generating equipment is decreased, and as the price of coal, the costs of haulage, loading and unloading, and power plant wages and management expenses rise, the prices charged for electricity will also rise. It is estimated that by the year 2000, the price of electricity in these areas will break through the 1 yuan per kWh barrier. The cost will become unbearable for users, and China may also lose its competitive advantage of low electricity prices.

What we have described above is a rather widespread model for the development of electric power; when there is a power shortage, step up the scale and pace of power plant construction, and if funding is insufficient, contract more debts. There is little or no consideration of the user's ability to bear the costs. This is an example of "one-aspect" thinking, in which attention is concentrated exclusively on increasing capital; we might describe it as a policy of "walking on one leg."

But there is another model for developing the electric power industry, which considers both the construction

of new power plants and the conservation of electricity by users, using mature energy-saving technologies to mitigate the user's accelerating consumption of power. An equal emphasis on development and conservation, walking on two legs, has already been adopted by most of the industrially developed countries.

2. Mature, powerful and far-reaching techniques for saving energy include energy conservation in lighting and adjustment of the speed of power equipment.

We shall begin by considering energy conservation in lighting, briefly analyzing its effectiveness and making some comparisons. In 1990, the total amount of electricity used in the society for illumination was about 60 billion kWh, representing 9.6 percent of total national consumption of electricity. The base load for lighting in the society was about 27.30 million kW or about a fifth of national generating capacity. In 1992, the annual energy consumption for lightning was more than 70 billion kWh.

China's immense potential for energy conservation in lighting is evident from its electric lamp use structure, which is primarily based on incandescent lamps, and from the low levels of illumination that are used. In 1992, the country's total output of light bulbs was 3.28 billion units, up 17.6 percent from 1991. The output of ordinary incandescent bulbs was 2.27 billion units, or 69 percent of the total, with fluorescent lamps accounting for only 8.7 percent. Thus, the ratio of incandescent to fluorescent lamps was 8 to 1. By contrast, the figure in Japan is 1 to 2; for every 1,000 incandescent bulbs produced in Japan, 2,000 fluorescent lamps are produced.

Current illumination levels in China are very low. The illumination level in residences of large and medium-size cities is 50 to 100 lux (a measure of illumination, representing the luminous flux per square meter), and that in classrooms, offices, and most commercial and service establishments is 100 to 150 lux. In small towns and the countryside, illumination levels are very low. After a long investigation that took account of physiological needs and psychological characteristics, an expert group of the International Electrical Commission (IEC) recommended illumination levels of more than 300 lux. Thus, China's current illumination levels are between five-sixths and two-thirds of the international standard.

It is forecast that total residential space nationwide in the year 2000 will be 40 percent greater than that in 1990, and that there will be a comparable increase in the area of public buildings. Indoor and outdoor lighting levels will approximately double. If no conservation of electricity in lighting is practiced, the base lighting load will increase by 80 percent and will account for 30 percent of the total generating capacity of 250 million kW in the year 2000. Energy consumption for lighting principally represents peak load, and if an emphasis is not placed on energy-conserving lamps, then 40 percent of the 120 million kW of new generating capacity that will be built during the 1990s will be eaten up during the peak evening hours, by lighting. In other words, if we do

not practice energy consumption in lighting, by the year 2000 the evening peak load may necessitate power shutoffs or cutbacks. In the above discussion we have primarily analyzed the result of building new power plants without practicing conservation and have shown that development will not be able to keep pace with growing needs. Below we shall compare the investments required for industry expansion and conservation and their economic benefits.

The national-average cost of the construction of new power plants is about 4000 yuan per kW of capacity; it is more than 5000 yuan per kW in the case of imported generating equipment. If we also include the cost of transmission and transformer facilities and the cost of railroad and port facilities for coal transport, the annual cost is close to 6000 yuan per kW. But the total investment on energy conservation in lighting is 700 yuan per kW of capacity. These figures do not include savings on the cost of electricity or investments in environmental protection.

China's potential for saving energy in lighting is great. There are three main methods of doing so. One is the use of compact fluorescent bulbs (commonly called "energy-saving bulbs") and of standard tubular fluorescent lamps, in combination with ballast devices, as a replacement for incandescent bulbs in interior lighting. The second is the use of high-voltage sodium lamps or metal-halide lamps as a replacement for high-voltage mercury vapor lamps, high-power incandescent lamps, and iodine-tungsten lamps in large-area illumination. The third is the use of new types of incandescent lamp technologies, such as double-helix filaments, brightness-enhancing coatings and reflectors, as replacements for ordinary incandescent bulbs, and the use of high-reflectivity lamp fixtures.

Let us consider China's output of and market for compact fluorescent lamps. Since these lamps first appeared in 1979, their use has expanded rapidly throughout the world. Because of their high light efficiency, good color, small size, and long life, they are used extensively as a replacement for incandescent bulbs. China's output of these lamps in 1992 was 17 million units, only 0.5 percent of its total output of electric lamps, and 70 to 80 percent of them were exported. China's current production facilities use domestically developed semi-mechanized equipment and domestic materials, and although it is labor-intensive, the production cost is low. But the appearance of the lamps is poor and their quality is not uniform. In these respects they rank a grade lower than those produced abroad. Domestically produced lamps have a life of 2000 to 3500 hours, or at best 5000 hours; but the world standard is 6000 to 8000 hours, or even 10,000 hours. China has imported foreign equipment for producing compact fluorescent lamps, but for the most part without success. The plans for a breakthrough project involving an integrated system for the production of energy-saving lamps will yield prototype equipment at the end of 1995, but the targets that have been set for the project are rather low. China's huge potential market for energy-saving lamps has prompted

such major foreign companies as Philips from the Netherlands, General Electric, U.S., Matsushita, Japan, and Aosilanmu [??phonetic], Germany, to offer to participate in joint-capital production plants, in which they would hold the controlling interest. They are making energetic efforts to corner or largely control China's market for energy-saving lamps. Chinese enterprises producing energy-saving lamps will face major challenges and competition.

The use of compact fluorescent bulbs with an integrated electronic ballast as replacements for incandescent bulbs produces an especially great saving. The luminous efficiency of these fluorescent bulbs (the luminous flux per watt) is five times that of the incandescent bulbs, yielding an 80 percent saving on electricity. If such bulbs were disseminated throughout the country on a large scale, replacing one-tenth of all incandescent bulbs, the annual saving of electricity would be more than 20 billion kWh. With potential savings of this magnitude, why have they not been disseminated and popularized? The reason is that the one-time investment is too great. The integrated-ballast bulbs are produced in sizes from 5 to 18 W and have lifetimes of 5000 hours or more, but the factory price is 30 to 55 yuan each. The 25- to 100-W ordinary fluorescent bulbs have a life of 1000 hours but cost only 1 yuan each. Thus, the fluorescent bulbs have a lifetime five to eight times as long, but their cost is 30 to 55 times as great. The one-time cost is too great for city-dwellers, to say nothing of those in the countryside. But witnessing the waste of electric power is an anguishing experience.

How would it be possible to resolve this conflict? We suggest taking a period of 10 years and gradually disseminating the energy-saving lamps in order to achieve an annual saving of 60 billion kWh of electricity, but initially striving for a saving of 20 billion kWh, which would require an investment of only 5.8 billion yuan.

3. Under China's real circumstances, there are three alternative approaches.

The first approach is to follow the example of the industrially developed countries and have the power plants provide a subsidy to the users. When a user buys a compact fluorescent lamp, the power plant will subsidize half the price (about 20 yuan at domestic prices). The government allows the power plant to include this subsidy in its cost of producing power, and it can be included in the price charged for electricity. In this way, the power plant does not increase its load, and the money it collects from the people is used for the people.

From the standpoint of the power plant, each 100 kWh that it generates requires an in-house expenditure of 8 kWh, and line losses consume another 15 percent, so that the user receives only 78 kWh. Thus, when the user saves a kilowatt, the saving for the power plant is 128 kW, or 28 percent. In addition, residential lighting all comes as part of the evening peak load, and power shutoffs or cutbacks have a particularly great impact on the people. Power shortages occur primarily at peak hours, and the power plant's greatest costs are incurred

in trying to avoid shutoffs or cutbacks during these peak periods. Because they need to have generating equipment to cover the peak hours, and because this equipment operates for short periods, the depreciation costs, fuel costs, and labor costs to the plants are increased. If the peak load is decreased, the greatest benefit accrues to the power plant and the power grid; production costs become lower and the reliability and stability of the grid are increased.

The use of 9-W, 13-W and 18-W compact fluorescent lamps as replacements for 40-W, 50-W, 75-W and 100-W incandescent lamps would decrease the load on the power grid by respectively 30, 45, 60, and 80 W. Let us consider the use of the lowest-power (9-W) energy-saving lamps, to replace 40-W fluorescent lamps, saving 30 W in the load on the power system. The subsidy paid for each lamp is 20 yuan, so that the investment per watt is only 0.7 yuan. Building 30 W of generating capacity would require an investment of 120 yuan. But considering the costs of in-house power consumption, grid losses, and the like, a 30-W load at the user end actually requires an investment of 153.8 yuan, or an average of 5.12 yuan per watt. Energy-saving lamps last five to six years, and the lifetime of a power plant, according to state depreciation standards, is 20 years, so that three to four energy-saving lamps would be required over the lifetime of a power plant. The subsidy on four lamps is 80 yuan. Thus, the energy-saving lamps require a subsidy of 2.67 yuan per watt but decrease the load on the power grid, saving 2.46 yuan compared with the construction of new power generating facilities. In the case of a 300,000-kW generator set, then, the saving will be 575 million yuan, or nearly 50 percent. And this is only a static investment comparison, which does not take account of the construction of high-voltage power lines and urban low-voltage lines. In addition, no construction cycle is involved; the effect of introducing the energy-saving lamps can be realized immediately, and the user can save 18 yuan per year per lamp (assuming a price of 0.4 yuan per kWh).

The second method is to have the State collect a fee of 0.1 percent per watt. Each year, it would collect about 500 million yuan, which would be used exclusively to subsidize the purchase of energy-saving fluorescent lamps by households. Enterprises and institutions would not be subsidized. Every year, it would be possible to subsidize the purchase of a single lamp by 25 million households, so that in about five years, every household in the country would receive one subsidy. Over the course of 20 years, the users would obtain the benefit from saving energy in monetary form, and thereafter there would be no need for a further subsidy or for the 0.1-percent surcharge. Enterprises and institutions have their lights on for a longer period every day than residential users, and their annual benefit from energy conservation would compensate their expenditure on the energy-saving lamps. Those who would gain the most from the use of energy-saving lamps would be the users, and the government's responsibility would be to provide guidance.

Some up-scale guesthouses and business establishments in Shanghai have broadened the user of energy-saving lamps on their own initiative. The Xinjinjiang Inn in Shanghai began to use compact energy-saving fluorescent lamps in 1989, first in public areas such as corridors and large rooms where the lamps were always burning, and now also, to some extent, in guest rooms. The inn used a total of 3500 compact fluorescent lamps, representing 80 percent of its total number of lamps. The annual saving of electricity was 1 million kWh or 436,000 yuan. The average saving per lamp was 286 kWh or 125 yuan per year. The cost of each lamp was between 25 and 48 yuan. The Zhongbaiyidian commercial building in Shanghai took the occasion of a remodeling in late 1992 to replace 6000 40-W thick fluorescent tubes with 36-W thin tubes. It used 9-W to 13-W compact fluorescent lamps to replace 1200 incandescent lamps in its halls. Its annual saving on electricity is 250,000 kWh or 110,000 yuan. It keeps its lights burning for 13 hours a day, from 9 a.m. to 11 p.m. The much longer lifetime of the lamps is a far greater benefit even than the saving on electricity costs. The Yangguang Inn in Shenzhen bought Philips compact fluorescent lamps on the Hong Kong market, paying Hong Kong \$120 per lamp. Its experience with these lamps was that the saving on electricity and the decrease in overall load greatly exceeded the cost of the lamps.

The third method is to subsidize the purchase of energy-saving lamps, with the power plants bearing the cost of the subsidy and including it in their production costs, but not being allowed to raise prices for electricity, absorbing the costs instead. The actual effect would be to decrease the profits tax that the plants paid to the State; but the State would be able to recover this loss by virtue of a smaller investment in the construction of power plants and transmission facilities.

Most of the economically developed countries have implemented or are implementing energy conservation measures of this type under the name of "integrated resource programs." In these programs, the potential for energy conservation is treated as a resource and considered on the same footing as development, with the objective of obtaining the greatest benefit at the least cost. This policy is a way of "killing three birds with one stone," because it benefits the State, the enterprises, and the public. It should be vigorously promoted.

Vice Minister Cha Keming on Power Industry Growth and Environmental Protection

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[Article by Cha Keming [2686 0344 2494], Vice Minister of Power Industry: "Extract of Vice Minister Cha Keming's May 10th Speech at the National Power Industry Environmental Protection Workshop"]

[FBIS Translated Text] The State Council is very serious about the national policy of environmental protection. It was recognized as one of the 10 missions for the 1990s by the 14th Plenum of the Chinese Communist Party. After

the 1992 UN meeting on the environment and development, the Party Central and the State Council approved 10 major measures concerning environment and development to further define the path we must follow to ensure a coordinated growth of the economy with the environment. The People's Congress established an environmental protection committee last year to enact more legislation and monitor their enforcement. It was renamed the Environment and Resource Protection Committee. The State Council was also reorganized to eliminate and combine certain departments. However, the State Council still retains an environmental committee which meets quarterly to study and coordinate major environmental issues. It is agreed that environmental protection is a basic condition to sustain continued growth of the economy. As China's economy grows at such a fast pace, environmental problems become a pressing issue. In some areas, pollution and ecological destruction have directly threatened economic growth and are becoming limiting factors for economic and social development. To this end, it is essential to protect the environment while the economy grows. The electric power industry, on the one hand, must work hard to provide electricity to build our national economy, while on the other hand it must take necessary measures to protect the environment. It must accomplish both tasks, i.e., speed up the development of electric power and protect the environment.

The State Environmental Protection Bureau and the State Economics and Trade Commission held the second national industrial pollution prevention workshop in Shanghai last October. Premier Li Peng [2621 7720] sent a letter of congratulations to the meeting in which he pointed out that industrial production is the primary source of pollution. Prevention of industrial pollution is essential to an improved working and living environment and is a key to having a continuously growing and healthy economy. Industrial pollution is a moderately serious issue in China. In certain local areas and industries, it is even a very serious issue. As the economy grows, pollution control is becoming even more important. All levels of government and authorities must address this problem as a high priority issue. A variety of measures must be taken to monitor and control the environment in order to coordinate environmental protection with economic growth, and we must try to make real progress in the prevention of industrial pollution. In his speech to the meeting, State Council Member Song Jian [1345 0256], on behalf of the State Council, pointed out the accomplishments obtained in environmental protection and gave us a series of instructions with regard to issues such as how to adapt to the new trend to do more in pollution control, how to achieve clean production, how to establish a modern industrial civilization, and how to develop technology for environmental protection. The accomplishments, experience and existing problems in the treatment of industrial pollution were discussed in the meeting. The situation we are facing today was also analyzed. The objectives, missions and measures of pollution control in the 1990s were presented. In the meeting, the "decision by the State Council on further strengthening industrial pollution control" (draft) and the "industrial pollution control plan for the 1990s" were also revised.

In the meeting, each region, department and organization were asked to study and map out their missions, objectives and measures to control industrial pollution and to carry them out in a systematic, step-by-step and forceful manner. The targets for the 1990s must be higher than those in the 1980s. All key industries must prepare their own plans and assign responsibilities to different levels for implementation.

I. Correct Understanding Regarding Accelerating Electric Power Construction and Environmental Protection

To speed up electric power construction is to ensure a high rate of economic growth and to raise the standard of living. By the end of 1992, China had an installed capacity of 180 million kW and produced 815 billion kWh annually. As electric power construction is being accelerated, the power shortage situation in most areas is deteriorating. Power shortage is becoming a more acute "bottleneck" limiting our modernization effort. According to statistics, there is a 20 percent power shortfall. As of the end of 1992, the average per capita electric power is merely 646 kWh, which ranks 80th worldwide. There are 28 counties and 120 million peasants without access to electricity. In some areas, blackout is often used as a measure to limit the use of electricity. This even happens in Beijing. The main reason is that there is not enough installed capacity to meet the demand for electricity. To meet the needs of a fast growing economy and to improve the standard of living of our people, we must speed up electric power construction. Between 1995-1997, an additional 15 million kW of capacity will be installed every year. It will be raised to 20 million kW annually for 1998-2000. By the end of this century, China will have a total installed capacity of 300 million kWh. On the basis that the GNP grows at a rate of 8-9 percent and the power consumed to produce a unit of goods can be reduced by 8-10 percent, power shortage can be essentially alleviated nationally. All counties will be electrified and more than 95 percent of the rural households will have power.

Accelerating electric power construction is a natural consequence of social progress. The proportion of electricity in total end user energy consumption is an indicator of modernization. In developed nations, this ratio is usually at 15-20 percent. It is only 7 percent in China. In order to accelerate our modernization effort, we must work hard to raise this proportion.

The construction of power plants with large generators would be a strategic measure to accelerate electric power construction, to improve energy utilization efficiency and to protect the environment. Only 28 percent of the coal consumed in China is used to generate electricity with most of it being used in industrial boilers, furnaces and civilian applications. Burning coal directly is inefficient and it has a major impact on the quality of the environment. Large scale power plants are more energy efficient and pollutants can be controlled in concentrated areas. Building more urban thermal power plants to integrate the supply of heat and electricity can replace a large number of industrial boilers. This is beneficial in terms of energy conservation

and environmental protection. To this end, we have to raise the proportion of coal used to generate electricity. In the middle of a severe power shortage, although the government is limiting the construction of small scale steam condenser generators, some areas are still building them in order to keep their economy growing. Small units are not energy efficient and tend to have poor pollution control equipment. Measures must be taken to attract investment in large scale power plants to keep the development of electric power on a sustainable and healthy track.

Pollution control must be taken seriously as electric power is being developed. Coal accounts for 80 percent of the energy source for China's electric power industry. To develop electric power is equivalent to burning more coal and producing and releasing more pollutants. This puts more responsibility on the shoulders of the electric power industry to control pollution. By the end of the century, thermal electric power will reach 1.1 trillion kWh and coal consumption will be as high as 540 million tons. Pollutants produced will increase by severalfold and rigorous pollution control measures must be put in place. There are numerous power plants on the Chang Jiang delta and Zhu Jiang delta. Shandong has no water resource and essentially relies on coal and electricity. Acid rain is a serious problem in the southwest and power plants are burning high sulfur content coal. These areas are facing very serious environmental problems. To protect the environment and preserve it for future generations, environmental protection must be treated as a critical issue. We have not invested much in environmental protection, nevertheless, areas that have a serious problem, or are economically developed, can take the lead in investment. New projects should address this issue as well. Older power plants should be replaced by new larger plants. Power plants that are not scheduled to undergo renovation must spend their limited capital on the treatment of pollution. Developing hydroelectric power also involves ecological issues. In particular, cascade hydropower plants have an impact on a large area. Measures should be taken to minimize any impact on the ecological environment.

II. Raising Consciousness of Leadership to Enforce the Law

After over a decade, a series of environmental protection laws, regulations and standards has been put in place to provide the legal basis for monitoring and enforcement. The Ministry of Power Industry also issued a series of related laws, regulations and standards. To meet the needs of a social market economy, the government is in the process of revising these laws, regulations and standards. The purpose is to make sure that the industry will treat environmental protection as an important task as it profits from doing business, and to consciously enforce the law and to establish a self-constraining mechanism to shoulder the responsibility in environmental protection.

The People's Congress and the State Council have decided to conduct a nationwide inspection on the enforcement of environmental protection laws over a three-year period beginning last year. In the meantime, the media reports the results as the inspection moves along. The Central TV

Station has begun broadcasting a series on "Century Journey of Environmental Protection in China," which has been well received by the public and the Party Central and the State Council have been very pleased with this series. In the enforcement and treatment of pollution, the electric power industry is doing a fair job overall. In the second national industrial pollution prevention meeting, Council Member Song Jianguo, on behalf of the State Council, gave his approval of the work done by the electric power industry. However, there are still issues remaining to be addressed. Power plant pollution was shown on TV in a special episode on "Century Journey of Environmental Protection in China," which hurt the image of the electric power industry. All levels of leadership must pay special attention to this issue. The revelation of the problem is a positive factor for our environmental protection work. We must summarize our experience, study the issues and take effective measures to rectify the situation. More importantly, prevention should be the policy of environmental protection. The work must be done consciously on the basis of national, local and industry-wide requirements. All leaders must view the relation between electric power and environment from the legal perspective. To enforce the law, one must first study the law. There are numerous laws, regulations and standards concerning environmental protection. Because a market economy is, to some extent, an economy governed by laws, people in leadership positions must spend time studying and understanding the laws, at least the major ones. Without a good understanding, it is hard to consciously enforce the law. Moreover, we may not even know that laws are broken..

Each unit must perform in-house inspection in accordance with applicable laws and regulations. Once a problem is uncovered, it must be resolved quickly. Inspection is considered to be an education as well as a motivation. To this end, the electric power industry should organize unscheduled internal inspections.

III. Incorporating Environmental Protection as an Integral Part in Electric Power Production and Construction

Environmental problems are created as a result of production and construction and must be resolved likewise. To accomplish a resolution, the responsibility must be clearly assigned to certain plants. In the past, some electric power bureaus were very successful in this area by assigning responsibility and incorporating it into production and construction. Leaders of the Shanghai Electric Power Bureau and Shandong Electric Bureau signed letters of responsibility with the local governor and mayor which assigned responsibility to the power plants. Each power plant manager then assigned different groups with different responsibilities and conducted periodic inspections to make sure that the work was being done properly. This is a very effective way to make leaders at all levels feel the responsibility and urgency of having the work done right. Thermal power plants under the jurisdiction of Sichuan Electric Power Bureau were asked by the central and local governments to renovate their dust removers within a certain period of time. Despite a shortage of funding, the work was done on time by a competent staff because the

leadership was committed to this issue. Lianbi Power Plant in Jiangsu has a reputation for being a major polluter because it has always discharged ashes to the Chang Jiang. In order to solve this problem on schedule, the bureau chief took charge of the project personally. It stopped discharging ashes to the Chang Jiang on December 30, 1993, in order to fulfill his own promise. With responsibility, there is pressure. When the electric power bureau signs a contract with a power plant, not only must there be economic targets but also environmental protection tasks and periodic inspections in order to have power plant pollution under control. Environmental protection is an area of review for any power plant that is seeking a special designation. Without it, such designation should not be awarded.

In order to incorporate environmental protection into production and construction, we have to build up a corresponding mechanism. It was clearly defined in the second national industrial pollution prevention workshop and we must implement it thoroughly, as follows: each organization must identify its environmental protection leader; it must specify a mechanism to manage the work and to staff it with efficient professionals who are familiar with environmental protection. In the "three modifications," environmental protection agencies can only be strengthened, not weakened.

IV. Control of Pollutant Release With Technology

Coal is the primary pollutant generated by thermal power plants. In order to control the entire process, we must depend upon technology advancement to increase energy efficiency, reduce coal consumption and improve effectiveness of equipment employed in the process. One way is to develop larger generator units. Newly constructed units are primarily 300 and 600 MW units. In the future, 1,000 MW units will be built. Larger units have higher parameters, they consume less coal which improves energy efficiency and favors environmental protection.

Next, we have to speed up the renovation of existing medium and low pressure units. These units are outdated and consume more coal to operate. They also have ineffective pollution control equipment and are mostly situated in urban areas. They must be replaced with larger, more efficient units. In addition, the percentage of high quality coal used should be increased. As an open price structure for coal materializes, this may become possible. Every bureau should pursue the use of high quality coal which will reduce equipment wear and tear and produce fewer pollutants.

Every power plant must treat the end products. The major tasks involved in this include, the control of smoke, sulfur dioxide and nitrogen oxides. The electric power industry has, over the years, effectively controlled smoke release. Compared to 1983, the installed thermal power capacity has increased by 184 percent and the release of smoke and particulate only increased by 22 percent. The amount of dust discharge per 10,000 kW fell by 53.7 percent. Dust removal technology reaches a new plateau every five years. Desulfurization has begun in thermal power plants. Thermal power plants that are being constructed, undergoing expansion and being renovated must be equipped with electric dust removers. When desulfurization is

required, it must be equipped accordingly. Since 1996, all newly constructed thermal power plants, 300 MW or higher, must use novel combustors to control the production of nitrogen oxides. By the end of the century, pollution equipment in thermal power plants will be significantly improved. In the meantime, clean coal technology will be developed at an accelerated pace. IGCC demonstration power plants will be built to serve as a technological base for the clean production of electricity in the 21st century.

V. Taking Advantage of the Opportunity To Develop Desulfurization Technology

In 1993, a total of more than 5 million tons of sulfur dioxide was discharged by thermal power plants in China. According to our electric power plan, more than 10 million tons of sulfur dioxide will be released by thermal power plants in the year 2000. The sulfur dioxide problem has become a limiting factor in certain areas in China. Desulfurization is a necessary step in accelerating electric power construction. Two issues must be resolved before desulfurization can be put in place to control the release of SO₂. The first is our economic policy. It costs more to construct and operate a thermal power plant with desulfurization equipment. There is no other way to solve this problem other than trying to find a solution in the pricing of electricity. The second issue is the domestic manufacturing of desulfurization equipment. To control sulfur dioxide, laws and standards are the driving force, economic policy is the basis and technology and equipment provides the assurance. It costs more to import desulfurization equipment. However, it is initially necessary. Nevertheless, expanded use of the technology must have it rest domestically. As electric power is being developed at a rapid pace, more and more plants requiring desulfurization equipment are being built. Thus, it is urgent to bring the manufacture of desulfurization equipment into China. By 2000, it is estimated that 10,000-12,000 MW units will require desulfurization equipment and over 5 billion yuan of investment. If the government imposes stricter laws and standards to collect a sulfur dioxide release fee nationwide, more units will need desulfurization equipment. This demand brings a unique opportunity for desulfurization products that would help build up the desulfurization industry in the next few years. Breakthroughs are required to begin manufacturing such equipment in China in order to provide the necessary technology and equipment to control the release of SO₂. The government has already given priority to environmental protection products and desulfurization equipment is a key item. Every unit should take this seriously. The development and commercialization of desulfurization technology should obey the principle of development, importation, cooperation and innovation. However, innovation, at this stage, is not to pursue high, cutting edge technology. Rather, it is to pursue practical, reliable, economical technology that suits our needs. Commercialization should be done on the basis of past experience in domestic research and development and pilot plant construction, as well as on the digestion and absorption of imported equipment. The experience already gained in China is very valuable and we should take

advantage of what we already have and make the best use of it. To accelerate the commercialization process, it was decided to establish a desulfurization corporation. Design, development and production forces in industry will be organized with economical means to create an entity to undertake the product development work in order to compete in the marketplace.

Recently, several foreign manufacturers became interested in joint ventures in desulfurization. Some countries are also willing to provide low interest loans to support thermal power plants in China in their desulfurization projects. Relevant departments in the Ministry should create the necessary conditions to encourage a wide range of contacts and technological exchanges. However, guidance and coordination must also be strengthened to incorporate all imported equipment and joint design and manufacturing projects into the electric power industry growth plan to avoid pitfalls including repeated efforts, low technology level and waste of funds.

Coordinating Power Development and Environmental Protection

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[Article by Ran Ying [0373 3853] of the Planning Department of the Ministry of Power Industry: "Coordinating Power Development and Environmental Protection"]

[FBIS Translated Text] Environmental protection is one of China's national policies. The Chinese Communist Party and the government are very concerned about it and have it listed as one of the 10 major tasks of reform and construction in the 1990s by the 14th Plenum. In the 8th People's Congress, it was repeatedly stressed that environmental protection is a common concern shared by all people. We plan to stick to a policy of treating air, water and soil pollution in a coordinated manner to fix rural and urban environments and to actively pursue measures to prevent industrial pollution. After the 1992 UN Meeting on the Environment and Development, the Party Central and the State Council approved 10 major measures to deal with these issues. This further clarified the path of growth that we must follow in order to coordinate economic growth and environmental protection. The result is that more requirements are imposed on the electric power industry. The electric power industry is a polluting industry and any effort for environmental protection will have a direct impact on the quality of our environment across the country. Coal, however, will still be the major source of electric power for quite some time. This makes the environment a big issue as we attempt to accelerate the development of more electric power.

I. Review of Environmental Protection in the Past Decade

The past decade was one of an open door policy and was also a decade of rapid development of electric power. In order to follow laws, regulations and standards in force, environmental protection was always treated as a major

task. Since China is a developing nation, it is impossible for us to invest a great deal of resources in pollution control as in highly developed countries. A series of technologically proven measures to treat pollution was gradually taken on the basis of the situation. Newly constructed facilities are taking care of air, water and soil pollution all at the same time with new technology, while conserving energy and optimizing resource utilization. Pollution is essentially under control. There was improvement every year and a new plateau was reached every five years. Major accomplishments in environmental protection are as follows.

1. Smoke and Soot Treatment

The total amount of smoke released has been effectively controlled. In 1983, thermal power plants 6 MW or larger accounted for 34.5 million kW of total installed capacity and released 3.07 million tons of smoke. By 1993, the total installed capacity was increased to 98.11 million kW and the total smoke released was 3.77 million tons. Over 10 years, with a 184 percent increase of installed capacity, the smoke discharged only went up by 22 percent.

The amount of dust discharged per unit electricity generated has dropped substantially from 148.3 kg per 10,000 kWh in 1983 to 68.7 kg per 10,000 kWh in 1993. As a result of 10 years of effort, it decreased 53.7 percent.

Nationally, dust removal is becoming more efficient; from an average of 85 percent in 1983 to 95 percent in 1993, an increase of 10 points. It reached the goal of the Eighth 5-Year Plan two years ahead of schedule.

Our technology in smoke and dust control has reached a new plateau. Ten years ago, there were only 25 electric dust removers installed in China. By 1993, 316 units were installed. Within the past five years, almost all newly constructed, updated and expanded facilities have been using electric dust removers. Essentially, all China's thermal power plants are using high efficiency electric dust removers.

2. Sulfur Dioxide Treatment

Control of SO₂ has just begun. The two 360 MW units at Luohuang Power Plant, owned by Huaneng Corporation, are operating with the desulfurization apparatus in place which removes 65,000 tons of SO₂ daily. An experimental rotary dry spray desulfurization apparatus has been transferred to production at the Baima Power Plant and is being used. Progress is being made in the Sino-Japanese joint effort pilot scale desulfurization experiment at two thermal power plants. Construction is essentially completed at Huangdao and will begin soon at Taiyuan. Nijiang Power Plant is importing a circulating fluidized bed furnace from Finland. The German Government has completed a preliminary feasibility study on a loan for desulfurization apparatus for three power plants. Nanjing Xiaguan Power Plant has signed a contract to purchase desulfurization equipment from Finland. Although these projects have not yet produced a significant impact on reducing SO₂ level in China, yet it is a sign that China's thermal power plants are beginning to address the issue of desulfurization.

3. Ash and Slag Treatment and Utilization

The problem of discharging ash and slag into the river has essentially been solved. A decade ago, 50 power plants did not have ash disposal sites or stable end users. Ashes were discharged into the river. To date, 46 of them have stopped sending ashes to the river. The four power plants that are still doing so are taking measures to ensure that this problem will be completely resolved completely.

Policy and guiding concept leading to the utilization of ashes have been established. In the 1970s, ash utilization had just begun and was primarily focused on storage. The electric power industry worked hard to expand the range of applications for ash and to support local authority in using it. In the 1980s, both storage and utilization were emphasized. Last year, the Ministry of Power Industry switched the guiding principle to focus on utilization. We are encouraged to overcome various difficulties to keep on using ashes more efficiently in larger quantity.

The amount of ash consumption increases annually. In 1983, 7.20 million tons of ash and slag were used. By 1993, it had reached 29.93 million tons, corresponding to an increase of 2.0-2.5 million tons annually. Due to this change of policy in ash utilization, the government has issued a series of incentives which made it into a valuable resource.

4. Wastewater Treatment

Industrial wastewater (not including ash washing water) is getting closer to meeting the discharge standard. In 1983, only 30 percent of the industrial wastewater discharged by power plants met the discharge standard. After 10 years of treatment, it was raised to 70 percent.

The amount of ash washing water discharged per unit of electricity generated is reduced substantially. Ash washing water accounts for 80 percent of the wastewater discharged by an electric power plant. In order to reduce the amount of ash washing water, some power plants are using condensed phase ash transport technology and closed-loop recalculation system. In 1983, each 10,000 kWh required a discharge of 30 tons of ash washing water. By 1993, it was reduced to 14.6 tons.

Wastewater is being recovered and utilized as a resource. In 1990, a total of 390 million tons of wastewater was recovered. In 1993, it reached 710 million tons, corresponding to an increase of more than 100 million tons annually. This not only reduces water pollution but also saves a large sum of sewage treatment cost. It also contributes to the development of the power plant itself and to the economy of areas where water is in short supply.

5. Many Thermal Power Plants Are Pioneers in Environmental Protection

Datong Second Power Plant was named as one of the "10 best pollution prevention businesses in China" in the second national industrial pollution prevention conference. Seventeen power plants including Jinzhou Power Plant were named "environmentally beautiful plants" and "progressive national environmental protection businesses." Shenyang Thermal Power Plant was given an international

environmental award by Power magazine in the U.S. Nearly 20 percent of the electric power plants were praised by their provincial and city environmental protection agencies as progressive organizations.

Although encouraging progress has been made in environmental protection, however, we should not be too optimistic. There is still a great deal of work to do. The following problems need our immediate attention.

1. Sulfur dioxide released by thermal power plants is still essentially out of control. The amount of SO₂ released increases almost proportionally to that of thermal electric power. It is becoming a limiting factor for cities and areas affected by acid rain and high SO₂ concentration.
2. A number of old units located near major cities are outdated. They consume more coal, have ineffective dust removal equipment and discharge much more smoke than the standard allows.
3. Old plants are not meeting environmental protection standards due to historic reasons. Because of more stringent environmental protection requirements and a shortage of funding for renovation, they are falling far behind in this aspect.
4. Environmental protection teams were adversely impacted during the "Three Reforms" in certain bureaus and plants. According to our preliminary investigation, two electric power bureaus eliminated their only environmental protection position. Some electric power bureaus and power plants have very few low level environmental protection positions which seriously affects the stability of the team.

II. Basic Environmental Protection Tasks to the End of the Century

From this point forward to the end of this century, China's national economy will be growing at a very fast pace. This gives us the opportunity to accelerate the development of electric power. According to the electric power development plan, the total installed capacity in China will reach 300 million kW by the year 2000. Thermal electric power will still account for 80 percent of the overall installed capacity. On the other hand, due to increasing coal consumption, the amount of pollutants released will also rise substantially. In view of the fact that environmental protection requirements are becoming more stringent, it is a serious challenge to the rapid development of electric power industry in China.

1. Understanding the Situation

Control of SO₂ is a monumental task. It is estimated that 10 million tons of SO₂ will be discharged by all thermal electric power plants in 2000. This is the problem to overcome in the development of electric power. Acid rain is also a serious problem in certain areas. To control the spreading of acid rain, with the approval of the State Council, a SO₂ discharge fee is being collected in two provinces and nine cities. The environmental and resource committee of the People's Congress is very concerned about SO₂ pollution and is in the process of drafting an "atmospheric pollution prevention and treatment act." The

law will put a limit to the amount of SO₂ released by thermal electric power plants. The State Environmental Protection Bureau is drafting a stricter release standard and is ready to implement it in 1996. Therefore, desulfurization is a necessary measure for certain power plants that must reach a certain size while still meeting specific national and local discharge standards.

To meet the objective of preventing industrial pollution and to build a socialist market economy, environmental protection authorities will strengthen the enforcement of environmental laws with economic means. New measures adopted recently include raising the standard in order to expand the applicable range of pollutant discharge fee and collecting the full amount allowable by law, gradually implementing a sulfur dioxide release fee system nationwide, charging a wastewater discharge fee, spending the entire amount of pollutant discharge fee for compensation, implementing a discharge permit system, and rigorously monitoring industrial waste release. These measures will, on the one hand, improve pollution control and reduce pollutant discharge, however, on the other hand, they will also expose a shortage of capital to deal with the issue of environmental protection.

Environmental protection must be addressed when foreign capital is used to build factories. Since the environment is a global concern, an environmental impact assessment is required for every power plant that involves a loan from the World Bank, Asian Development Bank, Japan Overseas Joint Fund, or EC banks. It is considered an integral part of the project and requires more stringent pollution control measures than those currently in force in China.

2. Basic Mission

The overall objective of environmental protection in China by the year 2000 is to have the environment basically under control, i.e. to improve environmental quality in key urban areas and to slow down ecological deterioration.

The overall objective of industrial pollution prevention for the 1990s as defined in the Second National Industrial Pollution Prevention Meeting is to essentially control the growth of pollution by maintaining the discharge of major pollutants at the county level and higher to their 1990 levels; which is consistent with the strategic objective for environmental protection for the year 2000.

In order to ensure the overall objective of environmental protection as a nation and that of industrial pollution control, specific tasks and objectives for the electric power industry in the year 2000 are as follows:

Maintain the amount of smoke and dust released to the 1992 level, i.e., keeping it below 3.80 million tons, in order to ensure "no additional pollution from increased production." All power plants in key cities are currently meeting smoke and dust release standards. On the average, the national dust removal efficiency is as high as 97.5 percent and dust and smoke release is effectively under control.

By the end of the Eighth 5-Year Plan, three thermal power plant desulfurization demonstration projects will

be completed. Between now and 2000, desulfurization equipment must be installed in newly constructed thermal power plants in areas of fast economic growth, heavy pollution and severe acid rain. Units with a total capacity of 10,000-12,000 MW, either in operation or under construction, are equipped sulfur scrubbers. Sulfur dioxide will be preliminarily under control.

Industrial wastewater discharge meets all standards. Forty percent of the ash washing water will be recycled and ash washing water discharged will meet 70 percent of the standards.

Ash will no longer be released to rivers by the end of 1995 and efforts will be made to accomplish it ahead of schedule. All filled ash dumping sites will be cultivated or planted by 2000. Forty-five million tons of ashes will be utilized in total.

Old transformer fluid PCB stored in concentrated areas will be processed to essentially remove any environmental threat posed by this hazardous compound.

Measures will be taken to minimize any environmental and ecological impact in the construction of hydroelectric power plants.

III. Measures Taken to Control Pollution

The key to realizing the goals and objectives of an environmental protection plan is to prepare and implement a series of effective and practical measures that are enforceable. The principle is to focus on prevention and control and to implement an energy that favors environmental protection. We must insist on energy conservation and combine protection with treatment. We have to invest more in environmental protection equipment and take full advantage of its benefit. We need to rely on technical progress and enhanced management to minimize the release of pollutants into the environment.

Specific measures to be implemented include the following:

1. Improve electric power supply structure

Accelerate hydroelectric power plant construction by exploiting China's rich water resources. By 2000, the total installed hydroelectric power capacity will reach 80 million kW. Hydroelectric power plays a critical strategic role in improving our energy structure, reducing coal consumption and minimizing pollution. To this end, we have to provide incentives to accelerate the construction of hydroelectric power plants in order to attract capital.

Actively pursue nuclear power technology. Nuclear power is clean energy. A 1,000 MW nuclear reactor unit can replace 3 million tons of coal annually, eliminating the release of large amounts of smoke, sulfur dioxide and nitrogen oxides.

2. Improve efficiency to reduce coal consumption

On the average, China's thermal electric power plants consume nearly 100 g/kWh of coal as compared to those in developed nations because of the small number of large units. At the present time, only 50 percent of the

installed capacity is 200 MW or higher. In the future, only large capacity and high parameter units, i.e., 300 MW or higher, will be built to replace smaller units in service. Furthermore, co-production of heat and electricity will also be used in all renovation projects. By the year 2000, a total of 20,000 MW of medium and low capacity units will be upgraded. With these two fundamental environmental protection and energy conservation measures, coal consumption rate can drop gradually by as much as 50 g/kWh by the year 2000. Based on our projection of generating 1.1 trillion kWh of thermal electric power, approximately 60 million tons of standard coal can be saved, not only reducing the release of large amounts of pollutants and the pressure associated with processing such pollutants, but also saving a great deal of money for treatment.

3. Implementing a responsibility system to clearly define the role of a corporation in environmental protection.

In making the transition to a social market economy, an electric company becomes an independent economic entity that is responsible for its own profitability, operation, self-constraint and growth. Therefore, the leadership of each electric utility must not only take effective measures to optimize its earning but also to be responsible for treating pollution created by all power plants under its jurisdiction. On the basis of national, industrial and local requirements, the management must play a leading role in environmental protection and organize and implement its own pollution prevention plan. Companies that already signed environmental protection agreements with provinces and cities must work hard to fulfill all tasks specified in their agreements. Those who have not reached an agreement with the local government must automatically include this subject as an objective to be accomplished while they are in office. Specific contents and standards must be published so that they can be implemented at the plant level. A responsibility agreement must be filed with the ministry which will serve as the primary basis in its annual inspection.

4. Implementing "three simultaneous measures" to rigorously control new pollution.

In order to thoroughly implement the "three simultaneous measures," investors are responsible for ensuring that the project meets national and local standards. Engineering design organizations must be responsible for the design quality of the environmental protection facility. Builders and installers must be responsible for the quality of construction and installation of the environmental protection facility. If it fails to meet environmental protection requirements which results in fines, then its designer and builder must assume all economic consequences. If it is a result of poor management, the fine will not be allowed as a part of cost. It should come out of existing capital.

5. Using new technology to minimize release of pollutants

New generators constructed in urban areas will have electric dust removers. Studies will be organized to raise the efficiency of membrane dust removers to meet the new standard. After 1996, newly constructed units at 300 MW or above will use combustion devices that produce less nitrogen oxides to control their release. Accelerate the adaptation and domestic production of sulfur removing equipment for simple wet sulfur removal, wet desulfurization, semi-wet desulfurization, in-situ desulfurization by calcium injection, and PAFP smoke sulfur removal, in order to offer suitable technology and equipment for a particular power plant. The design of any new power plant must take wastewater recovery and recycling into consideration. It must create the necessary condition for coal ash utilization. Dried ash can be utilized at power plants when appropriate.

6. Strengthening management to raise the operating and maintenance level of electric dust removers.

There are 316 electric dust removers in China. Approximately 30 percent of them are not meeting their designed efficiency due to lack of proper maintenance. As electric power grows and installed capacity increases, more and more electric dust removers will be placed. By 2000, it is expected that 80 percent of the generators will have electric dust removers. Hence, to strengthen management and improve the operating and maintenance level becomes an important task. The operating and maintenance manual for electric dust removers issued by the ministry must be seriously implemented. Relevant personnel should be trained to manage dust and ash at the same time. All measures must be implemented and everyone responsible must be reviewed. The electric power bureau must issue yellow warning signs to power plants that cannot meet design requirements and are emitting black smoke for long periods of time and order them to resolve the problem within a set time limit.

7. Introducing a contract system to rapidly turn wastewater into a resource.

A thermal electric power plant discharges a large amount of water. There is great potential to reduce the amount of water discharged. Existing power plants must try to recycle their water and make modifications to their water discharge systems in order to minimize it to the extent that is economically possible. To accelerate the pace of turning wastewater into a resource, a contract system may be introduced just as with the utilization of ashes. It can be done either in the form of contract management or independent accounting. Before the government officially releases its incentive plan, each bureau may select one to two power plants as trial sites. To implement this contract system, every power plant must install a meter to measure the wastewater discharged within two years.

8. *Establishing desulfurization companies to produce sulfur removal equipment domestically.*

Imported thermal power plant desulfurization equipment is expensive. At the initial stage, it is necessary to purchase a number of such facilities abroad. However, it is unrealistic to rely on imported sulfur removal equipment to control sulfur dioxide emission in China. In order to meet the need of a rapidly growing thermal electric power industry, modern desulfurization technology and equipment must be quickly adapted and manufactured domestically. A decision has been made to establish a thermal power plant desulfurization corporation to recruit the necessary talent required to design, develop and produce such equipment. To satisfy the need of a social market economy and to compete in the market, the desulfurization industry must begin at a high level and follow a path that combines development, importation and international cooperation. We must avoid duplication of efforts at lower levels and disorganized importation of foreign products which lead to a waste of capital. At the startup stage, the corporation must be supported by the appropriate authority. However, it should not be a monopoly; competition should be encouraged.

9. *Building a modern environmental protection team to balance the growing electric power industry and environmental concerns.*

A highly competent and qualified team of professionals must be built up in order to accomplish our well defined objectives in environmental protection. We must rectify the situation that a few bureaus and power plants have eliminated their environmental protection posts during the "three measures of reform" campaign. All levels of management must change their attitude towards environmental protection and give high priority to the buildup of a professional environmental protection team. On the basis of the new mission and requirements, a team of well-trained professionals should be put in place. A well-defined responsibility system must be put in place. Work on environmental monitoring and statistics must be done right and information must be exchanged freely to provide the basis for environmental management and pollution control.

Environmental assessment departments must raise the quality of their work. They must charge reasonably and be more competitive. Effort should be made to raise the quality of personnel in order to offer quality services.

10. *Enhancing international cooperation in environmental protection.*

We must take advantage of the present opportunity to enhance international cooperation in environmental protection with regard to power plants. Let us bring in technology and capital, and provide personnel training, to push the level of pollution control forward.

Power Supply Could Increase by 10.7 Percent in 1994

40100005A Beijing CHINA DAILY in English
7 Oct 94 p 2

[Article by Chang Weimin: "Electricity Suppliers Turn Up Capacity"]

[FBIS Transcribed Text] China is likely to generate 900 billion kilowatt-hours of electricity this year, a 10.7 percent rise over last year.

Ministry of Power Industry spokesman Jiang Shaojun said at least 600 billion kilowatt-hours have already been produced so far this year.

And during the January-August period, generators with 4.7 million kilowatts of capacity were installed, Jiang said. An additional 6.3 million kilowatts of capacity will be installed this year.

Four major power projects will be launched by the year 2000. They are: Joining all regional and provincial power grids into a united national network. [As published]

China now has five regional grids in the northern, north-eastern, eastern, central and northwestern parts, covering 20 provinces, autonomous regions and municipalities.

The other 10 provinces and autonomous regions such as Shandong, Guangdong and Fujian have their own power dispatch systems.

The government originally expected a national network early the next century. The release says the linkage will be completed before the year 2000 as high economic growth requires.

For that, development of super-high voltage power transmission is necessary.

—Extending power supply to all rural areas. Now, rural areas accommodating 120 million farmers have no power supply.

For that, the government encourages economically booming provinces to invest in power plant construction.

—A nationwide campaign to promote the development of energy saving products and adoption of measures to use electricity economically.

—Developing clean coal firing technology, which is set as a major research and experiment item in policies decided by the State Planning Commission and the State Science and Technology Commission.

China produces 1.1 billion tons of coal a year. The development of clean coal technology is of great significance as coal constitutes 75 percent of energy consumption.

To guarantee the long-term goal, the industry has decided on focus points in operations for the next six years. They include:

—To improve the industrial structure and accelerate construction of hydropower stations to reduce environmental pollution and alleviate pressure on coal transportation by railways.

—To build several large thermal power plants near major coal mines in the provinces of Shanxi, Shaanxi, Henan, Guizhou and Yunnan and the western part of the Inner Mongolia Autonomous Region, all being major coal producers.

Electricity generated there will go to cities and provinces such as Beijing, Tianjin, Hebei, Guangdong and Shandong.

—To tap nuclear power resources further and build pump storage power plants.

By the year 2000, construction of nuclear power plants capable of producing a total of 8-10 million kilowatts per hour will have been launched.

Two nuclear power plants, in Guangdong and Zhejiang provinces, are now in operation, capable of generating a combined 2.1 million kilowatts per hour.

Further breakthroughs in the industry are expected with the introduction of foreign funds and the reform of the electricity pricing system.

Foreign Investment Assists Power Industry Development in Chang Jiang Basin

946B0165B Beijing *RENMIN RIBAO OVERSEAS EDITION* in Chinese 26 Jul 94 p 1

[Article by reporter Xia Shuge [1115 1859 7041]: "Chang Jiang Basin Vigorously Utilizing Foreign Capital to Develop Hydropower"]

[FBIS Translated Text] The Chang Jiang basin is vigorously using foreign capital to develop hydropower in order to put an end to electricity shortages.

Officials of the electric power departments in the area told us that in recent years, Anhui, Jiangsu and Zhejiang provinces and Shanghai city, all on the middle and lower reaches of the Chang Jiang, have made progress in using foreign capital to develop the power industry. They have signed 18 agreements or letters of intent with businessmen in the United States, the United Kingdom, Germany, Singapore, and Hong Kong for joint-capital power industry development, which will result in a total installed capacity of 16.30 million kilowatts. These jurisdictions are currently using more than \$1 billion of foreign capital to build 4.1 million kW of generating capacity. In addition, they have built a 500-kV superhigh-voltage transmission line that runs a distance of 600 km from Xuzhou to Shanghai. Meanwhile, Sichuan and Hubei, in the middle and upper Chang Jiang valley, are vigorously following suit, accelerating their use of foreign capital for power industry construction. Power plants and power stations are holding discussions with foreign businessmen who express enthusiasm over the prospects.

The large river-basin economy that is coming into being along the Chang Jiang, China's longest river, has a decisive

position in the national economy, but electric power development in the region was long unable to meet the needs of economic development and the people's condition of life. As a result, while increasing the investment of domestic funds throughout the region, the new approach of using foreign capital to develop the power industry was also adopted.

Officials from the electric power departments describe two main features of the use of foreign capital for electric power development in the Chang Jiang basin. The first is that large-capacity equipment, consisting of 300- to 600-MW sets, is being installed. For example, two 600-MW generator sets have been installed at the Yangzhou No. 2 power plant. The second is that the equipment is technologically advanced: for example, the two 600-MW generator sets installed at the Shidongkou No. 2 power plant in Shanghai are advanced supercritical units with low coal consumption and high efficiency.

Authoritative departmental sources have announced that in the next five years, China's electric power industry will grow by 8 to 9 percent annually; but the pace may be even more rapid in the economically developed Chang Jiang basin, and the use of foreign capital for power industry development is likely to accelerate.

In Jiangsu, Zhejiang, Shanghai, and Anhui, foreign capital is now funding 22.8 million kW of power industry construction, equivalent to 70 percent of these areas' current capacity. In Sichuan, the use of foreign capital for the power industry began only recently, but in the next seven years the province plans to add an additional 10 million kW of generator sets, which will require an investment of 73 billion yuan. Since last year, more than 100 outside financial groups or corporations have visited Sichuan to discuss investment in electric power.

U.S. Company Invests in 2400-MW Hainan Power Plant

946B0165C Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 15 Aug 94 p 2

[Article: "Sanya Uses Foreign Capital to Build Power Plant and Port"]

[FBIS Translated Text] Sanya, China's southernmost city, will make use of foreign capital to build an electric power plant with a total capacity of 2400 MW and a port with a handling capacity of 29.1 million tons.

The U.S. Saide [phonetic] Electric Power Company, the Hainan Province Electric Power Corporation, the Western Hainan Electric Power Corporation, and the Xinya Development Corporation of Sanya will cooperate in building the Meishan Power Plant in Sanya. The Western [as published]

Electric Power Design Institute of the Ministry of Power Industry will be in charge of project design.

The finished power plant will have a capacity of 2400 MW. The first stage will consist of two 150-MW generating sets and will require a total investment of \$3.5 billion, of which 75 percent will be provided by the Saide company. The plant's main fuel will be natural gas from the South China Sea. This is the largest use of foreign capital to date at Sanya.

The Nanshan port at Sanya will be designed by the No. 2 Maritime Project Survey and Design Institute of the Ministry of Communications. The planned handling capacity of the port is 3.27 million tons in the year 2000 and 29.1 million tons in 2020. The total investment will exceed 600 million yuan, and the principal source of funding will be foreign government loans.

Turpan-Hami Basin Production Could Hit 3 Million Tons This Year*946B0159A Shanghai WEN HUI BAO in Chinese
23 Jul 94 p 1*

[Article by Zhang Zhirong [1728 1807 2837]]

[FBIS Translated Text] Construction of China's first modernized oil field under first-rate world-class development and management, has now begun on a large scale in the Turpan-Hami Basin in Xinjiang. By year's end the Qiuling oil field will be finished and in production, and Turpan-Hami could see a crude oil production capability of over 3 million tons.

The Turpan-Hami oil field is one of the key development oil fields in the Eighth 5-Year Plan. Qiuling oil field, located in the center of the major oil field area, the third oil field to come under development on the Turpan-Hami scene in early 1991, was designed for a production capability of 1.4 million tons under a total investment of 1.87 billion yuan, and includes one joint station built for a 1.6 million ton output capability and an oil, gas, water, and electrical system with advanced domestic and foreign facilities. There, on the edge of the "infernal" Gobi, records are being rewritten as 12 drilling teams among the 32 drill rigs deployed over the area have broken the 10,000-meter barrier. Large-scale construction began at Qiuling oil field this year, and of the 80 wells drilled to date, 43 are already producing.

Pinghu Update*946B0159B Hangzhou ZHEJIANG RIBAO in Chinese
12 Jul 94 p 1*

[Article by Jin Rong [6855 2837]]

[FBIS Translated Text] East China Sea oil and gas prospecting brings more good news as the Wubei-1 well, drilled in the first half of this year, has now brought up a commercial oil and gas flow. This proves that the Pingbei oil and gas development zone, where Wubei-1 well is located, may succeed the Pinghu oil and gas field as another possible oil and gas development zone.

The Pingbei oil and gas zone in the East China Sea is located 345 kilometers due east of Ningbo. In the 1980s, after the Pinghu oil and gas field was discovered by geology and mining departments and approved for development by the State, the Pingbei area north of Pinghu came under closer scrutiny with high-sensitivity prospecting, and five successive exploration wells turned up high-output industrial oil and gas flows there, offering obvious prospects for oil and gas resources. Experts believe that the Wubei-1 well, having likewise turned up flows of industrial oil and gas, compounds the prospects for oil and gas resources in the 1,500-square-kilometer Pingbei offshore zone. Further appraisal will establish the Pingbei offshore area as a second prospective oil and gas area.

Donghai Field in Tarim Is Nation's First To Be Fully Automated*946B0159C Urumqi XINJIANG RIBAO in Chinese
16 Jul 94 p 1*

[Article by reporters Chen Chen [7115 2525] and Cheng Lixin [2052 4539 2450]]

[FBIS Translated Text] The first oil field in China fully automated with advanced world-class 1990s vintage facilities, the Tarim Donghe oil field, was completed and started production on 27 June, and by 15 July it had produced and processed 23,000 tons of crude oil. This signals a new plateau for the construction of China's oil production capability.

Donghe oil field, located about 95 kilometers west of the Lunan subsection, is a key national construction project, under a total investment of 270 million yuan for a designed annual production and processing capability of 1 million tons. Most of the facilities at the oil field are imported from abroad, and all of it is automatically controlled so that only 30 people are needed to run the entire oil field. The Sichuan Petroleum Construction Corporation, one of the premier national-level oil-construction outfits in the country, undertook the construction of the oil field, and although work began last June, for various reasons, delivery of imported facilities did not get rolling until April of this year. With much to do on short schedule, the call went up for "quality management and engineering," and crack troops were brought in from the Zepu and Lunan work sites. The Corporation, working 14-hour days from the latter part of May to install the fire prevention facilities which was expected to take at least 28 days, finished the job in just seven days, and the American fire-prevention expert, Mr. (Maruoou), who was doing the on-site debugging work, gave it a worthy "thumbs up."

Oil-Bearing Structures Verified in Taklimakan*946B0165A Beijing RENMIN RIBAO OVERSEAS
EDITION in Chinese 28 Jul 94 p 1*

[Article by reporter Li Dadong [7812 1129 2639]: "Oil-Bearing Structures Verified in Taklimakan"]

[FBIS Translated Text] As a result of several decades of difficult work, China's geologists can now use desktop computers to provide drilling crews with detailed on-demand information about the surface and subsurface geology of most of the Taklimakan desert. In the Luntai zone in the northern part of the desert, the drilling crews have used geological data to site 47 wells, almost all of which have produced showings of oil. This success rate is on a par with advanced world petroleum exploration standards.

The Taklimakan desert, the world's second-largest desert of shifting sand, which is located in the Tarim Basin of Xinjiang, swallowed up more than 20 ancient kingdoms. In the late 1970s and early 1980s, several desert geology exploration teams, composed of engineering and technical personnel from the Northwestern Geology Bureau of the Ministry of Geology and Mineral Resources and the No. 3

Geological Survey Bureau of the former Ministry of Petroleum, entered the Taklimakan region to shoulder the heavy task of finding a reserve petroleum supply for China.

The preliminary statistics show that the petroleum geologists have performed two-dimensional seismic surveying on profiles with a total length of more than 160,000 km, three-dimensional seismic surveying in an area of 1800 km², and desert gravimetric surveys on profiles with a total length of more than 30,000 km, have constructed nine seismic profiles crossing the desert, and have performed 1:25,000 scale aeromagnetic surveys of the desert, radiochemical explorations, special well logging studies, and other surveying work. In addition, they have laid out more than 3,500 satellite global positioning system reference points in the desert, representing a density of one every 10 km, and have matched world standards for rapidity of positioning and accuracy of coordinate-system conversion. They have subdivided the region into seven basic structural elements, consisting of "three uplifts and four depressions," and have established stratigraphic and structural databases for them. Structural data on the top several thousand meters of geologic strata beneath the desert are now essentially in hand.

Senior engineer Liu Guoliang [0491 0948 2733] told us that the Xiaya and Bachu oil-containing uplift belts were identified in the western part of the desert and that an oil- and gas-bearing stratum 300 m thick was later found at Yueshan. Subsequent drilling located a high-productivity commercial reservoir of oil and gas in a stratum at a depth of 5,391 m, providing scientific well-siting data for the main petroleum development force.

U.S., Japanese Investors Eye Yunnan Oil and Gas Opportunities

946B0165D Beijing RENMIN RIBAO OVERSEAS
EDITION in Chinese 19 Aug 94 p 2

[Article by reporter Ma Tianze [7456 1131 3419]: "Yunnan Province Has Significant Oil and Gas Resources, Attracting US and Japanese Interest in Development."]

[FBIS Translated Text] Yunnan was long thought to have little oil and gas. But after more than 30 years of unremitting exploration efforts, on 1 June of this year the first major gusher was obtained. In light of this gratifying news, a recent meeting of the provincial governor's office made arrangements to accelerate the development of a province-wide petrochemical industry.

At the beginning of the year, the Yunnan-Guizhou-Guangxi Petroleum Exploration and Development Corporation began drilling the Lucan No. 1 well in a paddy field at the Dazuizi work site, located at Sanchahe village, about 15 km from the county seat of Luliang County. At 1:01 p.m. on 1 June, as the well reached a depth of 595 meters, a major gusher suddenly occurred, producing an immense column of fire at the wellhead. The flames reached a height of more than 50 m, lighting up half the sky, and continued to burn for more than two weeks. Experts view this gusher, the first of its magnitude in Yunnan, as a major piece of good news, indicating that the Luliang Basin has abundant reserves of

natural gas. When the news was announced, more than 10 potential investors from this country and from the United States, Japan and Hong Kong reportedly expressed great interest in cooperative development and utilization of Luliang's natural gas. The China Petroleum and Natural Gas Corporation will be intensifying exploration efforts in Yunnan.

Japanese Banks Extend \$50 Million Loan To Explore Reserves in South China Sea

40100001A Beijing CHINA DAILY in English
27 Sep 94 p 1

[Article by Liu Weiling: "Japanese Loan Aids Oil Fields"]

[FBIS Transcribed Text] The China National Offshore Oil Corporation (CNOOC) was given a \$50 million loan yesterday to explore reserves in the South China Sea.

The syndicated loan was put up by five Japanese banks: the Sumitomo Bank, the Sanwa Bank, the Mitsubishi Bank, the Sakura Bank and the Industrial Bank of Japan.

The money will be used to develop Liuhua 11-1 oil field in the eastern part of the South China Sea, and two other fields off Huizhou in Guangdong Province, CNOOC officials said.

This is the second loan given in recent months. A \$50 million loan was granted by the Fuji Bank on August 22.

The Liuhua 11-1 oil field, one of the country's largest, was discovered by CNOOC and the U.S. oil company Amoco Corp.

The field has a verified oil deposit of 150 million tons that requires \$650 million of investment. It is expected to become productive in April 1996 and produce 2.7 million tons each year.

The oil fields in Huizhou, coded 32-2 and 32-3, were explored by CNOOC and the ACT group, composed of the Italian company Agip, and the U.S. oil giants Chevron Corp. and Texaco Inc.

The fields, which are 5 kilometres apart, will require \$300 million of investment over a three-year construction period.

The projects will use some of the equipment being used by the Huizhou 21-1 and 26-1 oil fields.

The two fields are expected to become operational next September and produce up to 1.5 million tons each year.

CNOOC officials said the country's offshore oil production has gained momentum in recent years as more oil fields are discovered and put into operation.

The company's crude oil output is expected to reach 6.5 million tons this year, compared with 4.63 million tons produced last year.

And experts predict that annual output may top 10 million tons by 1996 and 12 million tons by 1997.

The South China Sea has the most promising oil reserves in the country, yet only a few fields have been discovered.

The East China Sea is also expected to see a surge of drilling and exploration activities in the first half of next year, thanks to last year's round of successful international bidding.

Oil Giants Join East China Sea Rush

40100003A Beijing CHINA DAILY (BUSINESS WEEKLY) in English 3 Oct 94 p 1

[Article by Yu Man: "Oil Giants Engaged in China Seas"]

[FBIS Transcribed Text] Development of China's offshore oil fields has consumed more than \$3.8 billion as the world's oil titans mass to tap the area's potentially vast reserves.

According to the China National Offshore Oil Corporation (CNOOC), \$2.6 billion has been spent on oil and gas exploration while \$1.2 billion was absorbed by oil development under way.

China has conducted four rounds of international bidding for offshore oil exploration and development and has secured 95 agreements with 55 companies from 15 countries, a CNOOC official said.

Another five contracts are expected by the end of the year. Joining the China rush are Amoco Corp., Chevron Corp. and Texaco Inc. of the United States and Agip of Italy.

The official said a surge of drilling and exploration activities by foreign companies in the East China Sea is expected to come in the first half of next year thanks to last year's round of successful international bidding.

At least eight contracts on oil exploration and development in the South China Sea are expected following CNOOC's opening of 13 areas there in June.

"Utilizing foreign capital and technology to develop China's offshore oil industry has for a long time been (our) firm strategy," the official said. And foreign capital and technology have helped China make strides in the industry over the past 12 years.

The two sides have drilled 338 wells in coastal waters of the East China Sea, South China Sea and Bohai Bay.

In addition to the 1.2-billion geological oil reserve, 145 billion cubic metres of natural gas have been explored.

Among the 20 oil and gas fields found, 12 have been put into production, including six in Bohai, three in the South China Sea and three in North Bay.

Estimated offshore oil production for this year is 6.5 million tons; the yield is expected to jump to 10 million tons in 1996.

Officials say China's offshore crude oil production will stabilize at 8 million to 10 million tons for 10 years after a peak yield of 12 million tons in 1997. And production of natural gas is expected to top 4 billion cubic metres in 1996. In the coming 15 years, annual production capacity of natural gas will reach 15 billion cubic metres.

"To reach the goals, CNOOC is encouraging more foreign cooperation to help it tap 400 million tons of geological oil reserves and 400 billion cubic metres of natural gas reserves by the end of the century.

Meanwhile, a Sino-U.S. petrochemical joint venture is expected to be approved by the State in the near future.

With total investment of \$5.4 billion, the factory will refine 8 million tons of crude oil and produce 450,000 tons of polyethylene and 10 kinds of refined chemicals every year.

Oil Imports Expected To Escalate

40100003B Beijing CHINA DAILY in English 3 Oct 94 p 2

[Article by Wang Yong: "Imports of Oil Expected To Escalate"]

[FBIS Transcribed Text] Fast economic growth is expected to necessitate the import of 100 million tons of crude oil per annum by 2010, a senior government official said.

For a considerable time, China's oil output has been unable to provide sufficiently for the nation's economic growth, said Li Boxi.

By the end of this century, crude oil imports will hit 50 million tons, according to Li of the State Council's Development Research Centre.

"The situation can hardly change for the better if no new big oil fields are tapped," he said.

On average, the nation's annual economic growth rate is expected to be 7.5 percent from 2001 to 2010. From 1996 to 2000 it is expected to be 8.5 percent, down from the likely 11 percent 1994 year-end figure.

Li said a major factor to be considered is that international oil prices have been close to China's domestic prices over some time.

But in past decades, domestic crude oil was sold at a lower price under the central planning economy.

But the new economic order is forcing oil prices to become more market-oriented.

Crude oil from the Tarim Oil Field, one of China's latest finds, is likely to be sold domestically at international price levels when it comes on tap.

Last year, China imported nearly 16 million tons of crude oil, almost balancing its export volume. Crude oil varies in quality, hence the need to both export and import different weights, light and heavy, for the petrochemical industry.

Although crude oil imports slowed somewhat in the first half of this year, it was only a temporary braking, experts said.

As social investment rebounds and factory inventories are trimmed, imports will surge again, they forecasted.

China's proven oil reserves stand at 78.7 billion tons. Natural gas proven reserves are 33,000 billion cubic metres.

But neither of the figures are sufficient considering the nation's huge population and demand.

According to Zhang Yongwi, vice-president of the China National Oil and Natural Gas Corporation, it should be China's long-term strategy to tap both domestic and overseas oil resources.

"Time is ripe for Chinese oil enterprises to go overseas for exploration and oil field construction," he said.

He proposed that while allowing greater access to Chinese markets for foreign investors, other countries and regions should respond with reciprocity.

So far, China has opened more than one-fifth of its territory to overseas oil investors.

Oil and Gas Output Up in First 9 Months of 1994

40100007A Beijing CHINA DAILY in English
14 Oct 94 p 2

[FBIS Transcribed Text] XINHUA—China increased its crude oil and natural gas output slightly to 108 million tons and 12 billion cubic metres, respectively, in the first nine months of this year.

According to the latest statistics from the China National Petroleum Corp. (CNPC), China's onshore crude oil output in the first three quarters hit 104 million tons, fulfilling 75 percent of the whole year's plan.

Natural gas output amounted to 11.7 billion cubic metres, completing 76 percent of the target for this year.

The China National Offshore Oil Corporation (CNOOC) revealed that offshore crude and natural gas output in the January through September period topped 4.67 million tons and 270 million cubic metres, respectively, with both figures exceeding last year's totals.

CNOOC said offshore crude oil output for the whole year is expected to reach 6 million tons.

A CNPC official said the strategy of "stabilizing oil output in East China while enhancing development in the West" has had initial success.

Oil production in large fields in the East, such as Daqing, Huabei and Liaohe, remained at roughly the same level as

last year, whereas those in the West, including Turfan-Harmi and Tarim, recorded a 20-percent increase.

Black Gold Still Flows From Daqing Oilfield

40100010A Beijing CHINA DAILY (BUSINESS WEEKLY) in English 24 Oct 94 p 5

[FBIS Transcribed Text] (XINHUA)—The Daqing Oilfield in Northeast China's Heilongjiang Province is still a pillar of the country's oil industry after 35 years of development, according to CHINA PETROLEUM JOURNAL.

From the first gush of black gold in 1959, crude oil output from the Daqing field has risen to 55.9 million tons last year, about 40.1 percent of the year's national total.

In the past 35 years, the oilfield has generated more than 1.2 billion tons of crude oil, roughly 50 percent of the national total during that period.

So far, 35 oil and gas fields have been located in the Daqing Oilfield and its adjacent areas, 18 of which have gone into commercial operation.

Meanwhile, some 25,000 oil wells and pump stations have been built on an area of 2,000 square kilometres and oil pipelines have extended more than 46,757 kilometres.

Officials said the Daqing Oilfield has pumped great vigor into the growth of the national economy.

From 1960 to 1993, the oilfield turned in more than 86.9 billion yuan (\$10 billion) in taxes to the government, about 32 times the amount of funds the government invested in the project during the same period.

Since 1982, crude oil from Daqing has been exported to more than 40 countries and regions, making a total of some \$36.6 billion in foreign exchange earnings.

Official sources put the oil output from Daqing, which first topped the 50 million ton mark in 1976, at 56.1 million tons this year.

Oil experts said that stable Daqing oil output has a direct bearing on the steady growth of the national oil industry.

Sources from the Daqing Oilfield have pledged to raise the oil output there above the level of more than 56 million tons a year before the year 2000.

Study on Counter Current Extraction Process of Highly-Enriched Uranium

946B0128A Beijing HE HUAXUE YU FANGSHE
HUAXUE (JOURNAL OF NUCLEAR AND
RADIOCHEMISTRY) in Chinese
Vol 16 No 2, May 94 pp 68-74

[Article by Wang Jianchen [3769 1696 2525], Jiao Rongzhou [7155 2837 3166], and Liu Bingren [0491 4426 0088], (Institute of Nuclear Energy Technology, Qinghua University, Beijing, 102201); and Wang Sulan [3760 4790 5695] (Beijing Institute of Nuclear Engineering, 100840)]

[FBIS Translated Text] A study of the continuous counter-current process for extraction of highly-enriched uranium using a critically-nuclear safe multistage mixer-settler has yielded distribution curves for uranic acid that comport well with the results of test-tube cascade experiments. The interfacial height and contact area ratios were measured, and the liquid surface peaks were under the critically nuclear safe threshold. The rate of uranium recovery was greater than 99.9 percent, and the extraction efficiency of tank 1A was greater than 85 percent.

There has been some question concerning critical safety in the solvent-extraction cycle process for highly-enriched uranium. Besides the limiting factors that apply to concentration and quality, the facilities for extraction have to be critically safe and attention must be given to their geometric dimensions to guarantee the safety of the operational process.⁽¹⁾

Based on a comprehensive analysis of the good and bad points of the mechanical agitator type of mixer-settler (see Document [2]), a structurally-simple and critically-safe mixer-settler was developed. The height of its diphasic liquid levels did not exceed 60mm, its critical safety was very good, it had a steady flow, a wide range of operational flow, and a high rate of extraction. The extraction facilities used in the experiment were the improved products of those described in Document [2]. In order to prevent the diphasic cascade flow in the ante-compartment at the bottom of the mixing chamber (the heavy phase reverting back at the entrance of the light phase before entering the mixing chamber, or from the light-phase reverting back to the entrance of the heavy phase) from affecting the efficiency of extraction, and to have more clearance for the upflow in order to be critically safe, the diameter of the diphasic-flow entrance was further reduced, and the agitator rotation speed was increased to (350-450r/min). The experiment of solvent extraction-cycle (uranium, plutonium depollution cycle) was completed in the 38-step critically-safe mixer-settler.

1. The Experiment

1.1 Reagents and Apparatus

Tributylphosphate (TBP): analytically pure; kerosene: 240#; uranyl nitrate: grade-2 reagent, Shanghai Metal-working Factory; sulfamic acid: chemically pure, Beijing Central-West Chemical Plant; nitric acid: chemically pure,

Beijing Chemical Plant; 5% TBP-kerosene prepared in 5%TBP-kerosene solution, after which it was rinsed once in a 1:1 ratio with 5

NaCO₃, then rinsed once again with 0.01mol/l HNO₃, and finally neutralized with deionized water; ferrous sulfamate (Fe(SA)₂): a specified amount of sulfamic acid was weighed out and dissolved in 0.3mol/l HNO₃, an equal amount of iron powder was slowly added to the sulfamic acid while stirring until the reaction was complete, left it overnight in a brown bottle, and before the experiment began, a specific amount of nitric acid was added as needed; the 1AF, 1AS, 1BX, and 1CX components were prepared as listed in Table 1.

Metering pump: Hangzhou Zhijiang Scientific Instruments Factory. Critically-safe mixer-settler, 38 steps, plexiglass materials.

Table 1. Uranium-Plutonium Cycle Process Parameters

Tank 1A	Flow ratio: 1AF: 1AX: 1AS = 1: 0.65: 0.3, extraction step number: 8; rinse step number: 9
Tank 1B	Flow ratio: 1BF: 1BS: 1BX = 1: 0.5: 0.3, supplementary extraction step number: 6; reduction reverse extraction step number: 6
Tank 1C	Flow ratio: 1CF: 1CX: = 1: 0.5, reverse extraction step number: 9
1AF	U ₁ : 3.24g/l, AL(NO ₃) ₃ : 1.54mol/l, HNO ₃ : 0.6mol/l, flow rate: 3.0 l/h
1AX	5%TBP-kerosene, flow rate: 1.95 l/h
1AS	AL(NO ₃) ₃ : 0.65mol/l, NHO ₃ : 0.7mol/l, flow rate: 0.9 l/h
1BS	5%TBP-kerosene, flow rate: 0.975 l/h
1BX	Fe(SA) ₂ : 0.03mol/l, HNO ₃ : 3.1mol/l, flow rate: 0.585 l/h
1CX	HNO ₃ : 0.01mol/l, flow rate: 1.463 l/h

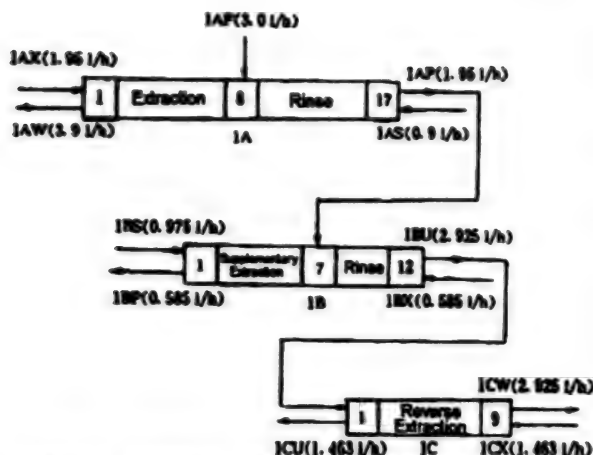
Note: natural uranium was used in the experiment.

1.2 Procedural Sequence

The procedural steps are shown in Graph 1. Following the highly-enriched uranium reprocessing flow,⁽³⁾ in tank 1A, the uranium, plutonium and fission fragment elements in the nitric acid solution are extracted with 5%TBP-kerosene to separate the uranium, plutonium, and fission fragment elements. In tank 1B, the 5%TBP-kerosene solution containing uranium and plutonium is reversely extracted with the 3.1mol/l HNO₃ containing 0.03mol/l Fe(SA)₂, to separate the plutonium from the organic phase. In tank 1C, the uranium is reversely extracted from the organic phase with the 0.01mol/l HNO₃.

1.3 Processing Parameters

The uranium and plutonium processing parameters are listed in Table 1. Because of the varying flow rates, in order to get a regular flow of material through each step within the tanks, the mechanical agitator arms were rotated at minimum speeds of 350 to 450 revolutions per minute at a temperature of 20° to 25°C.



Graph 1. Uranium, Plutonium Cycle Processing Flow

1.4 Methods of Analysis

1.4.1 Analysis of Uranium

The normal weight uranium ($>1\text{g/l}$) in the liquid and organic phases was titrated by potassium chromate oxidation-reduction titration method,⁽⁴⁾ and the microweight uranium ($<1\text{g/l}$), was analyzed by colorimetric analysis using azoarsenic III.

1.4.2 Analysis of Acids

The acidity was analyzed by NaF complexing of uranium and aluminum in a solution of aluminum nitrate, and acidity in the liquid phase was measured by the potentiometric titration method: a $V_1(\text{ml})$ sample was put into a 100ml flask, 20ml of 2%NaF was added and agitated, the pH value of the solution was measured with a pH meter, a 0.06mol/l concentration of NaOH standard solution was used to titrate the solution, and a pH -NaOH volume $V_2(\text{ml})$ curve was drawn. The largest value of $\Delta\text{pH}/\Delta V_2$ was used as the end point of titration at which the acidity of the sample could be calculated at $0.6V_2/V_1$. After the uranium was complexed with NaF, it was directly titrated with an alkali⁽⁴⁾ to measure the acidity of the uranium-containing liquid and the organic phases.

1.5 Procedures of the Experiment

1.5.1 At start up of the tanks, in accordance with the design requirements of the tank, it was decided that selecting the high-viscosity organic phase as the dispersion phase, and the liquid as the continuum phase would help to speed up settlement.

1.5.2 The extraction equilibrium between tanks was monitored by the determination of uranium concentration of the outlet liquid-phase IAW of tank IA, outlet liquid-phase IBP of tank IB, and the outlet liquid-phase ICU of tank IC, and the organic-phase ICW. According to the recovery rate requirements, the uranium concentration of IAW

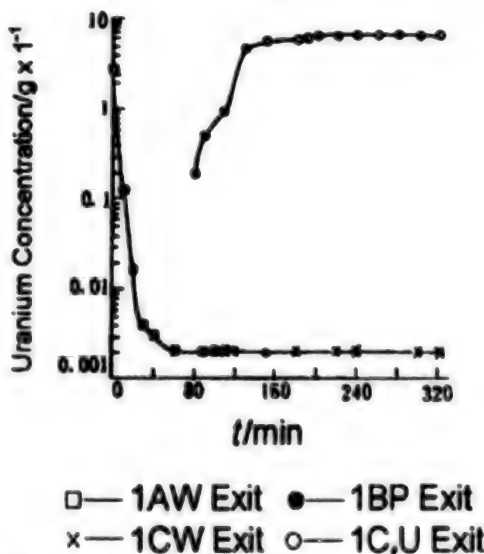
should be less than 0.0025g/l ; 1PB uranium concentration should be less than 0.0165g/l ; and ICW should be less than 0.0066g/l .

1.5.3 Sampling: (1) When the extraction process of each tank reached equilibrium the operation was continued for another half hour, and samples were then taken. When operations stopped, the acidity and uranium grade distribution were measured in the liquid and organic phases of each settlement chamber. (2) While the operation was in progress, about 10ml of solution from inside of each mixing chamber was centrifuged and measured for contact area ratios. (3) For each step, the interface height of leach settlement chamber and the height of the liquid at each gate were measured.

2. Results and Discussion

2.1 Monitoring of Extraction Equilibrium

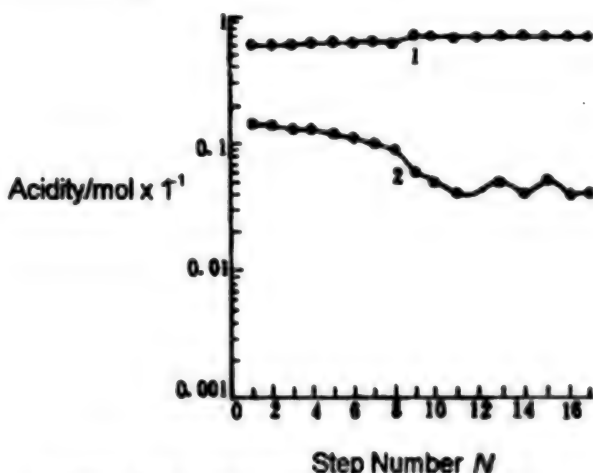
The experiment was timed from the point of putting materials into IAX. The curve delineating changes in concentration of uranium at the outlet of each tank is shown in Graph 2. Graph 2 shows the overall average concentration of uranium at IBP and ICW outlets throughout the experiment to have been less than 0.002g/l , which met the requirements for the experiment. When it started, there was uranium outflow from the IAW outlet which was caused by IAF and IAS being full, and liquid-phase outflow from the first step began only after the first step of extraction. As the length of time increased the uranium concentration in IAW gradually decreased. The uranium concentration at the ICU liquid-phase outlet increased with time, and finally tended to become constant. After more than three hours of operation, $t > 3\text{h}$, the three tanks reached equilibrium. The volumes of each tank were then: 3.3 in IA; 2.3 in IB; and 2.9 in IC.



Graph 2. Uranium Concentration Change Curve for Each Tank

2.2 Uranium and Acidity Distribution Curves for Each Tank

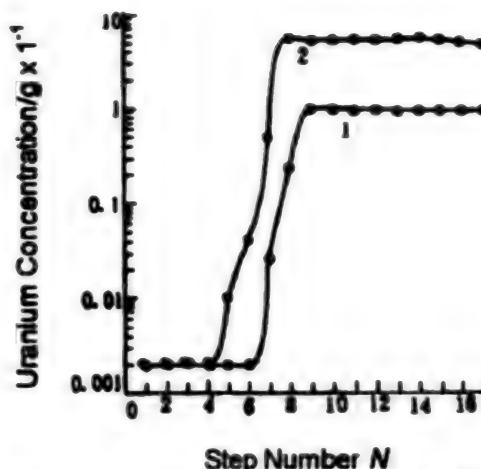
2.2.1 Tank 1A. The acidity distribution curve for tank 1A is shown in Graph 3, which shows that at each stage of the liquid phase the degree of acidity changed very little, and the acidity of the extraction stages in the organic phase were higher than the rinse stages, this being due to the low concentration of $\text{Al}(\text{NO}_3)_3$ in the rinsing agent, and because of its low salting-out action, the acidity in organic-phase extractions was also very slight. The uranium distribution curve for tank 1A is shown in Graph 4, which shows that the concentration of uranium in the extraction stages gradually reduced, and didn't change much in the rinse stage. After three extraction steps in the extraction stage, the uranium concentration of the liquid phase dropped to 0.002g/l, which met the uranium recovery rate requirements. When the differences in laboratory experiments and industrial production were considered, number of steps in the extraction stages could be more flexible. The uranium distribution in the various steps as obtained by this study fit better with those of the test-tube cascade experiment in Document [3].



Graph 3. 1A Tank Acidity Distribution Curve.

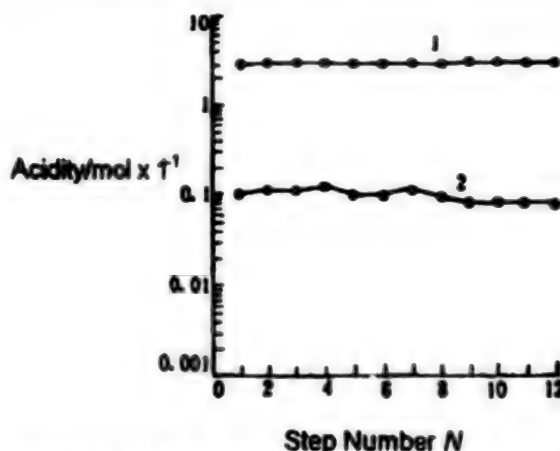
1. Liquid phase. 2. Organic Phase

2.2.2 Tank 1B. Because ferrosulfamate was used to reduce the reverse-extracted plutonium, in tank 1B, and also plutonium was easily reversely-extracted in the tank, only the progress of uranium was observed in this study, and plutonium was not added to the solutions. Graphs 5 and 6 show that in step 12 of tank 1B, the acidity averaged about 3mol/l in the liquid phase, with little variation, which meant most of the uranium was retained in the organic phase during reduction reverse extraction, and only a small amount of the re-extracted uranium of steps 1 to 6 was returned to the organic phase through supplementary extraction at 1B5, and a high recovery rate for uranium was guaranteed. The distribution figures for acidity and uranium in the various steps of tank 1B were very close to the data given in Document [3].



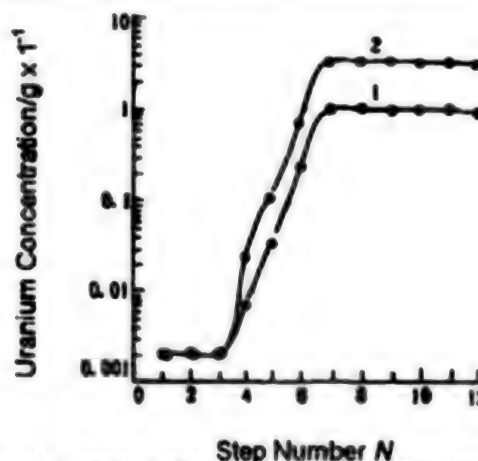
Graph 4. 1A Tank Uranium Distribution Curve.

1. Liquid phase. 2. Organic Phase



Graph 5. 1B Tank Step-Acidity Distribution Curve.

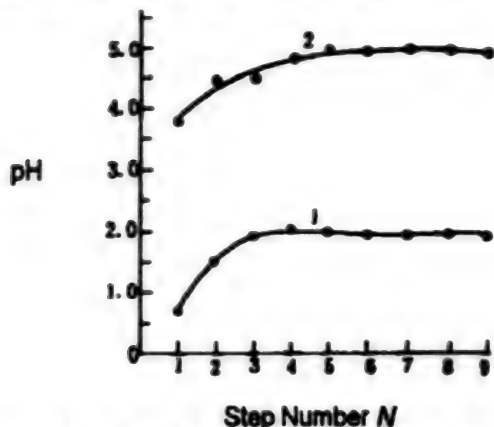
1. Liquid phase. 2. Organic phase



Graph 6. 1B Tank Step Uranium Distribution Curve.

1. Liquid phase. 2. Organic phase

2.2.3 Tank 1C. The reverse extraction fluid 1CX with 0.01mol/l nitric acid was added to the tank to reversely extract the uranium. Graphs 7 and 8 show that by the third step the acidity of the liquid phase had dropped to 0.01 mol/l, the acidity of organic phase dropped to a pH of 4.4 to 5.2, and after the fourth step, the uranium in the organic phase was nearly 0.002g/l, indicating that 99.9 percent of uranium was reversely extracted to the liquid phase.



Graph 7. 1C Tank Step Acidity Distribution Curve.
1. Liquid phase. 2. Organic phase

2.3 The Recovery Rate of Uranium of Each Tank and the Step-Effectiveness Rate of Tank 1A

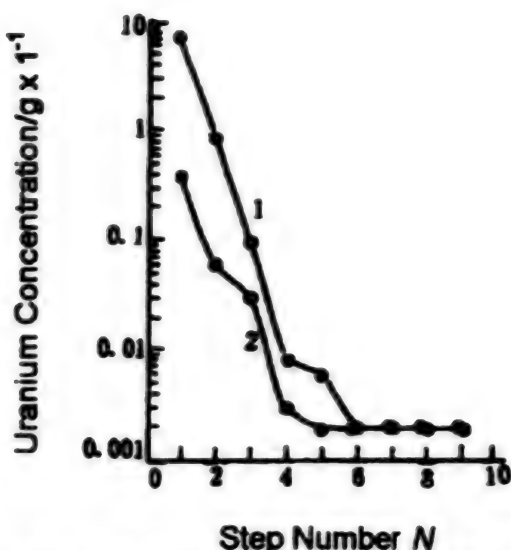
Uranium Recovery Rate = $\frac{\text{Uranium Content of Input} - \text{Uranium Content of Raffinate in Liquid Effluent}}{\text{Uranium Content of Input}} \times 100 \text{ percent}$ (1)

Document [5] Equation: $v = D(V/U) - 1/D(V/U)^{n-1}$ (2)

v is the residual rate of extraction; D is the distribution ratio; V is the organic-phase flow rate; U is the liquid-phase flow rate; n is the theoretical step number. The theoretical step number n is obtained from equation (2).

Step-efficiency-rate = $\frac{\text{theoretical } n \times \text{number } n}{\text{true } n \times \text{number } n} \times 100\%$

After the tanks were in equilibrium, the average uranium concentration at the outlets were less than 0.002g/l, which by equation (1) calculates out to a tank 1A uranium rate over 99.91 percent, over 99.99 percent for tank 1B, and over 99.93 percent for tank 1C.



Graph 8. 1C Step Uranium Distribution Curve.
1. Liquid phase. 2. Organic phase

From Graph 4 it is evident that after liquid-phase extraction step 3 in tank 1A the uranium concentration is less than 0.002g/l, meeting the required recovery rate, and the step efficiency rate of these three steps can therefore be calculated. The acidity of the extraction stages basically doesn't change, so the uranium distribution ratio of the extraction stages can be considered a constant, and the test-tube cascade distribution ratio was $D_U = 27$.

$v = 100\% - 99.91\% = 0.09\%$, calculates out to $n = 2.66$, and real step number $n' = 3$.

Step-efficiency-rate = $2.66/3 \times 100\% = 88.7\%$

2.4 Contact-Area Ratio, Interface Height and Height of Fluid Over Gates

The contact-area ratio and interface heights of 1A, 1B and 1C are in Tables 2 and 3. Table 2 shows the contact-area ratio of the mixing chamber of each tank at each step basically coincides with the flow rate of the corresponding steps. According to the hydraulics equation, if the effect of flow rate on interface height is disregarded, an equation can be derived from Graph 9.

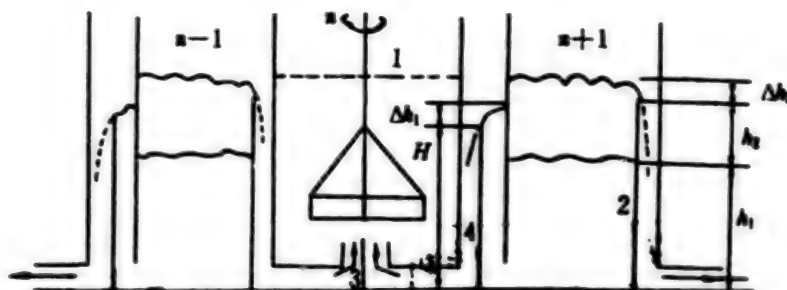
$$\rho_1 \Delta h_1 + H \rho_1 = h_1 \rho_1 + h_2 \rho_2 + \Delta h_2 \rho_2 \quad (3)$$

Table 2. 1A, 1B, 1C Contact Ratio

Mixing Chamber	1A			1B			1C	
Step number	1	8	17	1	7	12	1	9
Liquid Phase volume/ml	6.5	7.6	3.1	2.0	1.5	1.7	6.5	6.8
Organic phase volume/ml	3.1	3.8	7.6	3.6	8.1	8.7	3.4	3.5
Contact ratio	0.5	0.5	2.5	1.8	5.4	5.1	0.5	0.5
Flow ratio	0.5	0.5	2.2	1.7	5.0	5.0	0.6	0.5

Table 3. 1A, 1B, 1C Interface Height

Settlement Chamber	1A		1B		1C
Step number	1-8	9-17	1-6	7-12	1-9
Liquid phase height/cm	4.3	4.1	4.3	3.9	3.9
Organic phase height/cm	1.6	1.8	1.9	2.0	2.0
Total height/cm	5.9	5.9	5.9	5.9	5.9



Graph 9. Mixer-Settler Structure Schematic

1. Mixing chamber liquid level. 2. Light phase gate. 3. Partition. 4. Heavy phase gate.

In the equation h_1 and h_2 are respectively, the liquid-phase height and the organic phase height in the settlement chamber; H is the gate height in the liquid phase, for a given value; ρ_1 and ρ_2 are densities of the liquid and organic phases; and Δh_1 and Δh_2 are the liquid height above a gate. Therefore, h_1 and h_2 have relevance to ρ_1 and ρ_2 only when Δh_1 and Δh_2 reach a given value. In the settlement chamber, $h_1 + h_2$ has a constant value. The measurements obtained in the experiment for the fluid height over the gates of the liquid and organic phases averaged 2mm, and in the design $H = 52\text{mm}$ and $h_1 + h_2 = 57\text{mm}$. Therefore, the interface height of each tank and each step can be calculated according to equation (3).

Tank 1A: At steps 1-8, based on the concentration of $\text{Al}(\text{NO}_3)_3$ of 1.34mol/l and the estimated $\rho_1 = 1.286\text{g/ml}$ and $\rho_2 = 0.8\text{g/ml}$, $h_1 = 45\text{mm}$ and $h_2 = 12\text{mm}$ were calculated. At steps 9-17, based on the concentration of $\text{Al}(\text{NO}_3)_3$ of 0.65mol/l and the estimated $\rho_1 = 1.14\text{g/ml}$ and $\rho_2 = 0.8\text{g/ml}$, $h_1 = 42\text{mm}$ and $h_2 = 15\text{mm}$ were calculated.

Tank 1B: when $\rho_1 = 1.0\text{g/ml}$, $\rho_2 = 0.8\text{g/ml}$, $h_1 = 34\text{mm}$, $h_2 = 23\text{mm}$ were calculated.

Tank 1C: when $\rho_1 = 1.0\text{g/ml}$, $\rho_2 = 0.8\text{g/ml}$, $h_1 = 34\text{mm}$, $h_2 = 23\text{mm}$ were calculated.

The computed results basically match the test results listed in Table 3, the disparities can be attributed to errors made in gate-height processing and effects of acidity on density in the liquid phase.

3. Conclusions

- (1) It can be seen from the results of the experiment and the operational conditions of the tanks that: the design of the critically safe mixer-settler used in this experiment was sound, safe, stable in operation, and within the scale of the experiment conditions, the fluids in the tanks can be guaranteed not to exceed the designed safety height of 60mm.
- (2) The tanks have very high operational stability and flexibility, can function under rather varied fluidity conditions with stability, and the biphasic contact ratios in mixing chamber and material flow rates are basically consistent.
- (3) The recovery rate for each tank was above 99.9 percent.
- (4) The step-efficiency rate for the extraction stage of tank 1A was over 85 percent.
- (5) The uranium and acidity distributions of each tank fit very well with the results of the test-tube cascade experiment.⁽³⁾

References

1. M. (Bennidicete), F.H. (Pigefude), H.W. (Liwayi). Nuclear Chemical Engineering. Translated by Wang Dexi, Wang Fangding, Zhu Jiang, et al., First Edition, Beijing: Atomic Energy Press, 1988. 483.
2. Zhang Weibo, Jiao Rongzhou, Liu Bingren, et al. A Study of the Hydraulics and Mass Transfer Functions of the Multi-step Critically-safe Mixer-Settler. China Nuclear S&T Report. CNIC-00672, TSHUNE-0052 Beijing: Atomic Energy Press, 1992.
3. Hu Jingxin, Lin Bijian, Zhao Lugen, et al., 49-3 Element Reprocessing Reagent Extraction Cascade Experiment. Selected Items from the 1977 Nuclear Fuels Reprocessing Conference. Beijing: Atomic Energy Press, 1978. 64-78.
4. Yang Xin, Dai Weizhi, Wu Xien, et al. A Study of the Mass Transfer Functions of the $\text{UO}_2(\text{NO}_3)_2$ -30%TBP System in a Pulsed Extractor with a Baffle-Ringed Column. Nuclear Energy Technology and Design Institute, Department 202, Qinghua University. January 1993, Unpublished materials.
5. Li Yigui, Fei Weiyang, Li Zhou. Liquid-Liquid Extraction Process and Facilities. Vol 1. Beijing: Atomic Energy Press. 1985. 195.

Study on Kinetics of Extraction of Uranium (VI) With HDEHP and Liquid Surfactant Membranes Containing HDEHP as a Mobile Carrier

946B0128C Beijing HE HUAXUE YU FANGSHE
HUAXUE [JOURNAL OF NUCLEAR AND
RADIOCHEMISTRY] in Chinese
Vol 16 No 2, May 94 pp 75-81

[Article by Zhou Zuming [0719 4371 6900], Du Huiyang [2629 1979 5364], Wang Haifang [3769 3189 5364], Luo Ji [5012 0679]. (Department of Modern Physics, Fudan University, Shanghai, 200433)]

[FBIS Translated Text] The constant-interface cell (Lewis cell technique) was used to study the kinetics of the extraction of uranium (VI) from a sulfuric acid solution with di-2-ethylhexyl phosphonate (HDEHP)-cyclohexane, and emulsified liquid membrane containing (HDEHP) as a carrier. By analyzing the effects of the components of the aqueous, organic, and membrane phases, and the agitator speeds and temperature on the extraction rate, separate uranium (VI) extraction-rate equations were obtained for HDEHP extraction and for emulsion liquid membrane extraction. The extraction mechanisms for the two types of processing are compared and discussed. The study found that the solvent extraction process is diffusion controlled, and the liquid membrane extraction process is controlled by chemical reaction.

HDEHP is a highly effective acidic phosphate extraction reagent, and its extraction ability can be readily adjusted through a changing aqueous-phase acidity, and it is widely used in the separation and extraction of uranium (VI) and other metals. Its equilibrium of distribution in uranium

(VI) extraction has been studied in detail, but there are few reports on its kinetics of extraction. Fomin and others,^(1,2) have studied the kinetics of HDEHP in the extraction of uranium (VI) in 1mol/l H_2SO_4 solution, and it is believed that the concentration of sulfuric acid in the aqueous phase has an effect on the type of rate control in the extraction process, such as when $[\text{H}_2\text{SO}_4] \geq 1\text{mol/l}$, the extraction process will be controlled by chemical reaction, and when $< 1\text{mol/l}$, it will be controlled by diffusion. Until now, there has been no detailed research on the kinetics of uranium (VI) extraction under low-acidity conditions. Since the appearance of liquid membrane technology, HDEHP has been selected as the mobile carrier for both support-type liquid membranes and emulsion-type liquid membranes, and it has been used for the enrichment of uranium (VI) in phosphoric acid⁽³⁾ and other media.^(4,5) Kenichi and others,⁽⁴⁾ carried out measurements of rates of uranium (VI) extraction with HDEHP as a carrier in emulsion liquid membranes, but its extraction-rate equations and mechanisms await further study. This document presents rate equations obtained for solvent extraction and liquid membrane extraction processes through a study of the kinetics of uranium (VI) extraction from low-acidic sulfuric acid solution using HDEHP-cyclohexane and HDEHP as carriers in emulsified liquid membranes, and compares and discusses the extraction mechanisms of the two processes.

1. Experiments

1.1 Reagents

HDEHP, chemically pure, purified as per Document [6]; cyclohexane, analytically pure; T155(2-butadiene-imine), supplied by Shanghai Gaoqiao Petrochemical Corporation; uranyl sulfate solution, converted from analytically pure U_3O_8 , concentration demarcated by the ferrous-reduced potassium dichromate volumetric method; all other reagents were analytically pure.

1.2 Preparation of emulsified liquid membrane

Kerosene and a small amount of liquid paraffin were used as the membrane solvents. HDEHP was used as the mobile carrier, T155 was the surfactant, and sulfuric acid was used for the internal aqueous phase, and that produced a water-in-oil type of emulsion-liquid membrane. First, a specific volume of oil-phase solution was made up according to the required concentration, and it was put into a wide-mouthed plastic bottle with a cover, then with an electric agitator at (1,000r/min), and according to a specific droplet rate in oil (R_{01}), a specific volume of internal aqueous-phase solution was added, after which the agitation speed was increased to (4,000r/min) and the solution was stirred for 20 minutes. This produced a white-colored emulsified liquid-membrane. When the newly-prepared liquid membrane was used, the uranium (VI) extraction rate continued to increase as the time lengthened, and it took 20 hours for the extraction rate to stabilize, so liquid membrane was laid up overnight before use. The emulsified liquid membrane was very stable, and throughout the experiments there was no sign of it breaking down or having caused the acidity of the external aqueous phase to change.

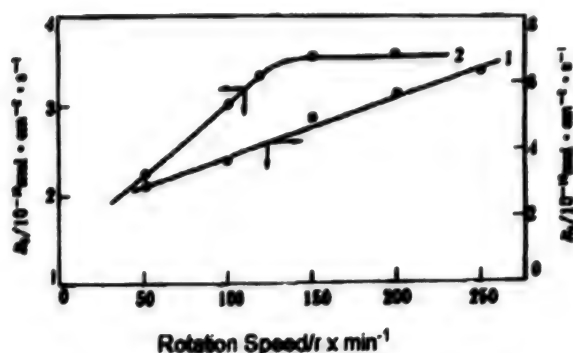
1.3 Measuring the extraction rate

The constant interface cell and the method of measuring the solvent extraction rate are given in Document [7]. When measuring the extraction rate of uranium (VI) by emulsified liquid membrane, the liquid membrane was used to replace the HDEHP-cyclohexane solution. In this document, R_1 was used for the beginning solvent extraction rate and R_2 for the beginning liquid membrane extraction rate—when the extraction process began, and the unit of time (s) through the unit of interface area (cm^2) was expressed as uranium (VI) volume (mol) being transferred from the aqueous phase or external aqueous phase mol to the organic phase or membrane phase. The experiment temperature was $30 \pm 1^\circ\text{C}$.

2. Results and Discussions

2.1 Distinguishing the mode of rate control

By measuring the effect of the constant surface cell agitator stirring speed and temperature on the extraction rate, the mode of rate control in the extraction process was identified. The extraction process controlled by diffusion increases its speed linearly as the rotation rate increases, and it is not very responsive to change in temperature. If the extraction process were controlled by chemical reaction, the extraction rate levels out at a certain high rotation speed, but it is more affected by temperature change. The effect of the agitator rotation speed on R_1 and R_2 is shown in Graph 1, which shows that the effect of agitating speed on the two are clearly different. As the agitator rotation speed increases, R_1 rises linearly; R_2 flattens out after the rotation speed reaches 150 revolutions per minute ($\geq 150\text{r/min}$). Experiment results show that R_1 and R_2 both increase as the temperature rises. According to the Arrhenius equation, $\ln R_1$ (or $\ln R_2$) - $1/T$ as shown in Graph 2, both ascend linearly. By calculating the gradient, the apparent activation energy of the solvent extraction was 19kJ/mol , and the liquid membrane extraction energy was 25kJ/mol . These findings suggest that the solvent reaction was diffusion-controlled, which matched the conclusions of documents [1,2]; and the liquid membrane extraction process is possibly chemically controlled. In order to determine the rate equations of the two processes under different modes of rate control, an agitator rotation speed of 100r/min was used for the solvent extraction, and 150r/min was used for the liquid membrane extraction process.

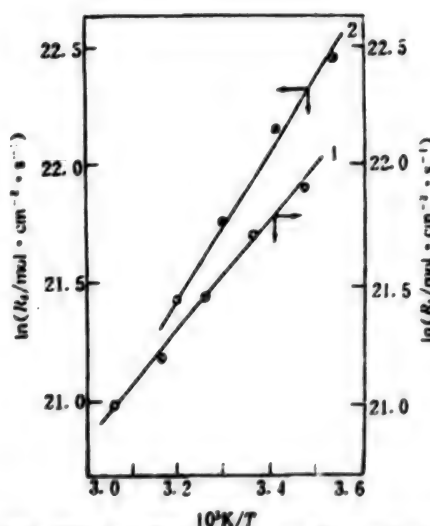


$$c_{\text{U}} = 4.84 \times 10^{-4} \text{mol/l}, \text{pH} = 2.00, c_{\text{HDEHP}} = 0.170 \text{mol/l}$$

1. Solvent Extraction: $c_{(\text{HDEHP})_{\text{org}}} = 0.05 \text{mol/l}$

2. Liquid Membrane Extraction: 0.05mol/l HDEHP:T155:Paraffin
(V:V:V) = 10:12, $c_{(\text{HDEHP})_{\text{org}}} = 1.5 \text{mol/l}$, $R_{\text{ex}} = 1:1$

Graph 1. The Effect of Agitator Rotation Speed on the Extraction Rate



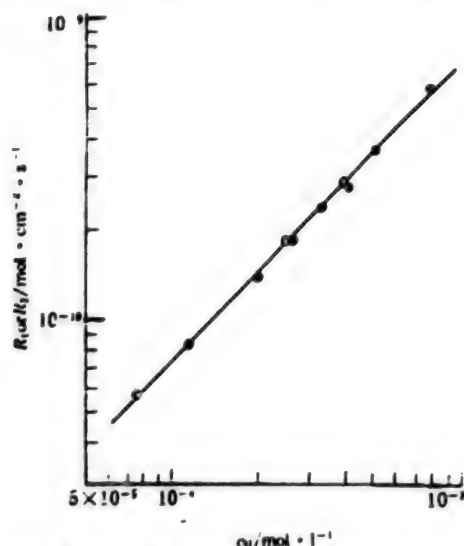
Graph 2. Effect of Temperature on Extraction Rate.

1. Solvent extraction: 100r/min . 2. Liquid membrane extraction: 150r/min . Other conditions as in Graph 1.

2.2 The effect of aqueous phase components

2.2.1 The effect of aqueous-phase uranium (VI) concentration

The effects of the aqueous-phase uranium (VI) concentration of the solvent extraction and the external aqueous-phase uranium (VI) concentration on the rate of extraction are shown in Graph 3. $\lg R_1$ (or $\lg R_2$) - $\lg c_U$ show a good linear relationship (the linear correlation coefficient is over 0.990), the gradient is 1.0, meaning R_1 and R_2 show a prime relationship to uranium (VI) concentration. Under the conditions illustrated in Graph 3, when the uranium (VI) concentrations are identical, the R_1 and R_2 values are similar, and the two $\lg R_1 - \lg c_U$ and $\lg R_2 - \lg c_U$ lines become one.



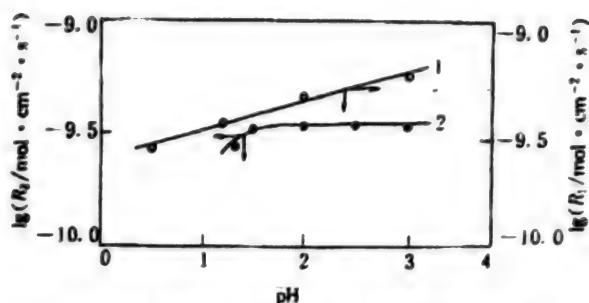
Graph 3. Effects of Uranium (VI) Concentration on Extraction Rate.

Empty circle: Solvent extraction; Solid circle: liquid membrane extraction. Besides U(VI) concentration, other conditions as in Graph 2.

2.2.2 The effect of aqueous-phase acidity

The effects of aqueous-phase acidity of the solvent extraction and the acidity of the external aqueous phase of the liquid membrane on the extraction rate is depicted in Graph 4. It shows that $\lg R_1$ rises very slowly or linearly as the pH rises, and the straight-line gradient computation shows R_1 is proportional to $c_{H^+}^{-0.08}$. When pH is 1 and 3, R_1 values are, respectively, 3.51×10^{-10} and 4.33×10^{-10} mol/cm² s, and the H^+ ion concentration drops 100 times, and the rate rises only 23 percent. When pH is in the range of 1.5-3.0, R_2 is almost constant.

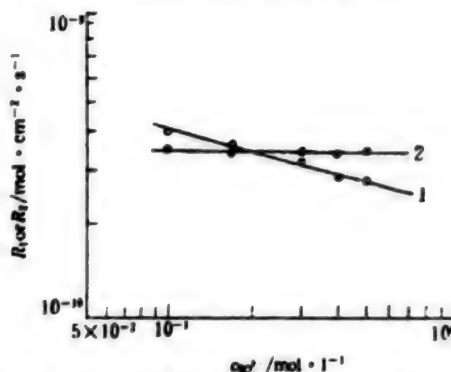
2.2.3 The effect of aqueous-phase sulfate radical concentration



Graph 4. Effects of Acidity on Extraction Rate.

1. Solvent extract. 2. Liquid membrane extraction. Other conditions besides acidity as in Graph 2.

The aqueous phase or external aqueous phase sulfate radical concentration has different effects on R_1 or R_2 (see Graph 5). In the range of 0.1-0.5 mol/l SO_4^{2-} , $\lg R_1$ follows $c_{SO_4^{2-}}$ in linear descent on a -0.26 gradient; R_2 does not change with the concentration of sulfate radical.



Graph 5. Effect of Sulfate Concentration on Extraction Rate.

1. Solvent extraction. 2. Liquid membrane extraction. Other conditions than sulfate radical concentration as in Graph 2.

2.3 The effects of organic-phase or liquid membrane components.

In the organic phase or liquid membrane oil phase, HDEHP takes the dimeric form of $(HDEHP)_2$, the concentration of which affects R_1 and R_2 as shown in Graph 6. $\lg R_1$ (or $\lg R_2$) - $\lg (HDEHP)_{2(0)}$ are having good linear relations (linear correlation coefficient is greater than 0.990). But gradient of $\lg R_1 - \lg (HDEHP)_{2(0)}$ line is very low, being only 0.19, while the gradient for $\lg R_2 - \lg (HDEHP)_{2(0)}$ is much higher, up to 1.0, meaning there is a prime relationship between the extraction rate and liquid-membrane phase $(HDEHP)_2$ concentration.

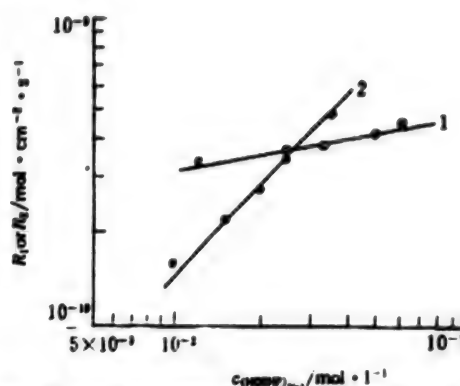
During the experiment, the proportionate volumes of HDEHP-kerosene, T155 and liquid paraffin were changed to study the effects of the surfactant and liquid paraffin concentrations in the liquid-membrane oil phase on R_2 . The results are shown in Table 1. It is evident from Table 1 that within the concentration range of this experiment the concentrations of surfactant and paraffin in the liquid-membrane oil phase have no effect on R_2 . The sulfuric acid solution as the aqueous phase in the liquid membrane was used for reversely extracting the uranium (VI) in the liquid-membrane oil phase. As shown in Table 1, when the concentration of the sulfuric acid solution increased from 0.5mol/l to 1.75mol/l, R_2 remained almost fixed, indicating the extraction rate is independent of the concentration of sulfuric acid solution of the internal aqueous phase. Under the prerequisite of maintaining stability of the liquid membrane, the proportions of components in the oil also have no obvious effect on R_2 .

Table 1. Effect of Liquid Membrane Components on Extraction Rate¹⁾

HDEHP-Kerosene ²⁾ : T155:Paraffin (V:V:V)	$C(H_2SO_4)_{aq}/$ $mol \times l^{-1}$	$R_{01} (V:V)$	$10^{10} R_2 / mol \times$ $cm^{-2} \times s^{-1}$
10:1:2	1.50	1:1	3.54
10:2:2	1.50	1:1	3.55
10:3:2	1.50	1:1	3.68
10:4:2	1.50	1:1	3.52
10:1:1	1.50	1:1	3.70
10:1:2	1.50	1:1	3.54
10:1:3	1.50	1:1	3.32
10:1:4	1.50	1:1	3.54
10:1:2	0.50	1:1	3.54
10:1:2	1.00	1:1	3.53
10:1:2	1.50	1:1	3.54
10:1:2	1.75	1:1	3.64
10:1:2	1.50	1:0.5	3.65
10:1:2	1.50	1:0.75	3.62
10:1:2	1.50	1:1	3.54
10:1:2	1.50	1:1.5	3.57

1) $c_U = 4.84 \times 10^{-4} mol/l$; $pH = 2.00$; $c_{SO_4^{2-}} = 0.170 mol/l$; 150r/min.

2) Because of the difference of volume ratio, the HDEHP concentration in HDEHP-kerosene is adjusted proportionately so as to make the HDEHP concentration in each liquid-membrane oil phase and its constitution 0.05mol/l HDEHP:T155:paraffin = 10:1:2. (V:V:V) to be consistent.



Graph 6. Effect of HDEHP Concentrate on Extraction Rate.

1. Solvent extraction. 2. Liquid membrane extraction. Other conditions than HDEHP concentration as in Graph 2.

2.4 Extraction mechanism

The rate equation that can be derived from the results of the experiment for the extraction of uranium (VI) by HDEHP-cyclohexane in a low-acidity ($pH = 0.5-3.0$) sulfuric-acid medium is:

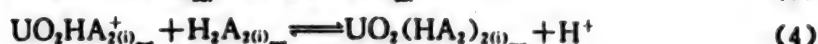
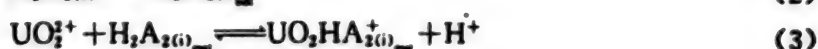
$$R_1 = k_1 c_U c_{(HDEHP)_{2(0)}}^{0.19} c_H^{0.08} c_{SO_4^{2-}}^{0.26}$$

In the equation, k_1 is the rate constant. R_1 , measured under varying conditions, yielded a computed average value for k_1 of $6.72 \times 10^{-7} mol^{0.15} \times 10^{0.85} / cm^2 \times s (30^\circ C, 100r/min)$. The extraction process is diffusion-controlled. The above equation shows that the value of R_1 is relative to the components of both the aqueous and organic phases, and because of this its velocity controller could be the diffusion process transferring the extraction compound $UO_2(HA_2)_2$ from the interface to the main body of organic phase. Raising the aqueous-phase uranium (VI) concentration, pH value, and organic-phase HDEHP concentration, and lowering the aqueous-phase sulfate radical concentration are all beneficial to complexing UO_2^{2+} ions and HDEHP at the interfaces, causing the concentration of extractant compounds at the interfacial areas to increase, and thereby increasing the rate of extractant compounds diffusion to the main body of organic phase, increasing the rate of extraction; and that was precisely the results of this experiment.

The rate equation for using HDEHP as the mobile carrier in emulsified liquid membrane for the extraction of uranium (VI) in low-acidity ($pH = 1.5-3.0$) sulfuric-acid medium is:

$$R_2 = k_2 c_U c_{(HDEHP)_{2(0)}}$$

In the equation, k_2 is the rate constant, computing the R_2 value derives k_2 with an average value of $3.86 \times 10^{-5} \text{ l}^2/\text{mol} \times \text{cm}^2 \times \text{s}$ (30°C , 150r/min). After the agitator rotation speed reaches $\geq 150\text{r/min}$, R_2 clearly reaches a flat kinetic level. It has a fixed temperature coefficient, is in balance with the concentration of the various components of the system, and has a dependent interrelationship with chemical reaction, and therefore the extraction process can be assigned to a chemically-controlled mechanism. Because the R_2 values have no relation to the sulfuric acid concentration of the internal aqueous phase, the uranium (VI) in the liquid-membrane oil phase and the reverse extraction reaction of the internal aqueous-phase H^+ ions cannot have functional control over the rate of extraction. The complexing reactions of the uranium (VI) in the external aqueous phase and interface molecules of HDEHP of the liquid-membrane oil phase are therefore the rate control measures of the extraction process. The sequential flow of the extraction process that can be deduced from the results of the experiment are as follows:



Equation (3) is the rate-control step of the extraction process. In that equation, (o), (i)_{out}, and (i)_{in} represent, respectively, the liquid-membrane oil-phase main body, the interface of the oil phase and the external aqueous phase, and the interface of the oil phase with the internal aqueous phase. Rate-control step (3) can be inferred from the sequential flow and the rate equation that tallies with the results of the experiment.

The forms of rate-control for liquid membrane extraction and the reagent extraction are different, and it could be because of an increase of diffusion rate when the extraction compounds that are produced during the liquid-membrane extraction are transferred from the interface of the external aqueous phase into the oil phase. Further study is needed.

3. Conclusions

- (1) The process of uranium (VI) extraction by HDEHP-cyclohexane in low acidic ($\text{pH} = 0.5\text{-}3.0$) sulfuric-acid solution belongs to diffusion-controlled process. Its rate equation is:

$$R_1 = k_1 c_{\text{U}} c_{(\text{HDEHP})_{2(o)}}^{0.19} c_{\text{H}^+}^{-0.08} c_{\text{SO}_4^{2-}}^{-0.26}$$

$$, k_1 = 6.72 \times 10^{-7} \text{ mol}^{0.15} \times \text{l}^{0.85} / \text{cm}^2 \times \text{s} (30^\circ\text{C}, 100\text{r/min}).$$

- (2) The process of uranium (VI) extraction from low-acidity ($\text{pH} = 1.5\text{-}3.0$) sulfuric-acid medium by liquid membrane using HDEHP as a mobile carrier is chemical-reaction controlled. Its rate equation is:

$$R_2 = k_2 c_{\text{U}} c_{(\text{HDEHP})_{2(o)}}$$

$$, k_2 = 3.85 \times 10^{-5} \text{ l}^2/\text{mol} \times \text{cm}^2 \times \text{s} (30^\circ\text{C}, 150\text{r/min}).$$

Reference Documents

1. Fomin, A.V., Yagodin, G.A., Tarasov, V.V.; Kinetics of Extraction of Uranium (VI) by Synergetic Mixtures DLEGFK and TBF. Radiochemistry, 1977, 19:645
2. Tarasov, V.V., Fomin, A.V., Yagodin, G.A.; Research on the Kinetics of Uranium and Zirconium Extraction Sulfate Solutions of Di-2-ethylhexylphosphoric acids. Radiochemistry, 1977, 19:753
3. Hayworth, H.C., Ho, W.S., Burns, W.A., et al.; Extraction of Uranium from Wet Process Phosphoric Acid by Liquid Membranes. Sep Sci Tech, 1983, 18:493.
4. Kenichi, A., Toshihiko, T., Takuji, K.; Extraction of Uranium Into Emulsion Liquid Membrane and Recovery by Demulsification. Bull Res Inst Miner Dressing Metal, Tohoku Univ., 1984, 40:11.
5. Zhang Ying; Research on Uranium in Emulsified Liquid-Membrane Purified Waste Water—The Effects of Membrane Phase Components and Membrane Producing Conditions. Excerpts of Papers from the First National Reagent Extraction Conference, Beijing, 1985. 219.
6. Sun Suyuan, Li Baoan; Extraction by the Chromatography Method and Other Applications. Beijing: Atomic Energy Press, 1982. 96.
7. You Jianzhang, Zhou Zuming, Qin Qizong; Research on the Kinetics of U(VI) Extraction from Sulfuric Acid Medium with HDEHP. Journal of Nuclear and Radiochemistry, 1988, 10:26.

Research on Fuel Elements for High-Temperature Gas-Cooled Reactor Said To Be at International Advanced Level

946B0153A Beijing ZHONGGUO HEGONGYE BAO
[CHINA NUCLEAR INDUSTRY NEWSPAPER]
in Chinese 11 Apr 94 p 1

[Article by correspondent Tian Li [3944 6849]: "Development of High-Temperature Gas-Cooled Reactor Fuel Elements Reaches Advanced International Level"]

[FBIS Translated Text] On 21 March, the high-temperature gas-cooled reactor fuel element developed by the Institute of Nuclear Energy Technology of Qinghua University, an "863" high-technology program, passed appraisal by the State Education Commission and was considered to be at international advanced levels.

The high-temperature gas-cooled fuel element is a new ceramic fuel element which ensures the safe and reliable operation of a high-temperature gas-cooled reactor. It is extremely complex and difficult to make and only a few countries have access to this technology.

The Institute of Nuclear Energy Technology at Qinghua worked on this development project for more than a decade. Gradually, key steps in this technology were brought under control to allow us to be among the leaders in the production of high-temperature gas-cooled fuel elements. It provided a theoretical basis and guidance to the development of fuel elements. In particular, the gelling of U_2O microspheres and the characterization of fuel particle coating involved a lot of studies and some creative results were obtained. This research defined a rational technical approach, conducted systematic experiments, obtained optimal process parameters, determined effective quality control criteria and developed performance testing means. After rigorous testing, the cold performance characteristics of the fuel element developed has met the design requirements for the HTR-10 reactor. It is at the worldwide advanced level for fuel elements of high-temperature gas-cooled reactors. Pilot production results showed that the process is stable and the technology is comparable to the original fuel element for the HTR-10 reactor.

First Phase of Yibin Large-Scale Nuclear Fuel Production Line Completed

946B0153B Beijing ZHONGGUO HEGONGYE BAO
[CHINA NUCLEAR INDUSTRY NEWSPAPER]
in Chinese 11 Apr 94 p 1

[Article by Wu Ji [0702 2817]: "First Phase of Yibin Large-Scale Nuclear Fuel Production Line Completed"]

[FBIS Translated Text] The Yibin Nuclear Fuel Element Plant has successfully completed the first phase of construction of a large-scale AFA17x17 nuclear fuel element production line manufactured by COGEMA of France. In addition, it has passed various qualification tests administered by COGEMA and professional appraisal by the appropriate department of the government and the Guangdong Nuclear Power Corporation. On 30 March, it successfully manufactured two blank elements that met our specifications, marking a new era of nuclear fuel production in China.

The Yibin Nuclear Fuel Element Plant is China's only nuclear fuel production facility. It independently produced the very first set of, and replacement of, high-quality, reliable fuel elements for the Qinshan Nuclear Power Plant, the first nuclear power plant constructed by China using its own technology. To meet the growing demand for nuclear power in China, the plant acquired the AFA17x17 fuel element production technology from COGEMA in 1991 to upgrade its existing production line. After two years of construction, a successful pilot run was completed on 8 September 1993. It passed 53 preliminary tests and final production evaluation in 2 stages, 30 process qualification tests, 5 qualification assessments and 6 product qualification tests.

Telegrams of congratulations were received from China Nuclear Industry Corporation, Guangdong Nuclear Power Corporation and COGEMA. The telegram from China Nuclear Industry Corporation pointed out that this is China's 40th anniversary of its nuclear industry and the 30th anniversary of its first atomic bomb explosion. Let us continue to cooperate with the experts from COGEMA to produce replacement fuel elements for the Daya Bay Nuclear Power Plant.

It was decided by representatives of the Guangdong Nuclear Power Corporation, China Nuclear Energy Industry Corporation, Yibin Nuclear Fuel Element Plant, and COGEMA that the first set of replacement fuel elements of Reactor No. 2 of the Daya Bay Nuclear Power Plant will be supplied by the Yibin Nuclear Fuel Element Plant. On the basis of the supply contract and the progress of the technology transfer agreement, the Yibin Nuclear Fuel Element Plant has decided to officially begin production on 6 April to ensure that replacement fuel elements for Reactor No. 2 of Daya Bay can be shipped from the plant on 20 January 1995.

Experts View Role of Nuclear Physics in China's Basic, Applied Research Fields

946B0153C Beijing ZHONGGUO HEGONGYE BAO
[CHINA NUCLEAR INDUSTRY NEWSPAPER]
in Chinese 9 May 94 p 1

[Article by correspondent Song Wenji [1345 2429 2638]: "Blueprint for the Ninth 5-Year Plan in Nuclear Physics"]

[FBIS Translated Text] According to nuclear physicists from Lanzhou Institute of Modern Physics, Shanghai Institute of Nuclear Research and Beijing Institute of High Energy Physics, who attended the nuclear physics planning meeting for the Ninth 5-Year Plan at the Chinese Academy of Sciences, nuclear physics is having a major impact on basic and applied research in China. A number of basic research facilities have been built. In the Ninth 5-Year Plan, we must stress innovation in cutting edge technology and work together to develop the necessary equipment to obtain some new accomplishments that are at world class level.

With giant progress in accelerator and nuclear detection technology, astonishing results have been obtained in nuclear physics with new levels and added degrees of

freedom. China is a recognized player in nuclear physics research throughout the world and should be able to maintain its standing in the Ninth 5-Year Plan and into the 21st century. Therefore, basic and applied research on nuclear physics will continue to be strongly supported.

Experts pointed out that nuclear physics is not only making remarkable progress within its own domain but is also deeply permeating other disciplines. It plays an important role in the development of other fields in physics.

Nuclear physics research and nuclear technology application in China has progressed significantly since the founding of the present government. It has contributed a great deal to our defense and the national economy. In recent years, we constructed several advanced large-scale experimental facilities such as the Lanzhou heavy ion accelerator and were recognized worldwide for a number of outstanding results in low and medium energy collision and thermal nuclear research, synthesis of nuclides away from the line of stability, heavy ion beam applications and medium and high energy physics research. The strategy, the guiding principle, the major fields of research and necessary conditions and facilities for the development of nuclear physics in the Ninth 5-Year Plan were discussed in the meeting. Experts hoped that the authority will strongly support the construction of a cooling storage ring and a secondary radioactive beam at the Lanzhou heavy ion accelerator and the development of a linear separation device and a detector system with detectors for 4π charged

particles, neutron and neutrino to ensure that the Institute of Nuclear Physics of the Chinese Academy of Sciences can maintain its superiority in worldwide competition in the Ninth 5-Year Plan.

Institute of Nuclear Energy Technology Signs Preliminary Agreements for Construction of Nation's First Experimental HTGR

95P60008A Beijing ZHONGGUO HEGONGYE BAO
[CHINA NUCLEAR INDUSTRY NEWSPAPER]
in Chinese 22 Aug 94 p 1

[FBIS Translated Text] On 24 June and 14 July 1994, the Institute of Nuclear Energy Technology of Qinghua University and construction companies 23 and 24 of the nuclear industry separately signed preliminary letters of understanding for contracts involving installation and civil engineering for the 10MW high-temperature gas-cooled experimental reactor.

Companies 23 and 24 have many years of experience in installation and civil engineering work involving all types of nuclear reactors and, in recent years, have enjoyed an excellent working relationship while handling the Institute's projects. The leadership of the two construction companies is paying very close attention to the nation's first effort to construct this new high-temperature gas-cooled reactor.

Ushering In New Prospects for Rapid Development of Wind Power

946B0155A Beijing ZHONGGUO NENGYUAN
[ENERGY OF CHINA] in Chinese No 7, 25 Jul 94 pp 1-5

[Article by Wang Shucheng [3076 1859 6134], Vice Minister, Ministry of Power Industry: "Raise the Curtain on a New Scene in the Rapid Development of Wind Power"; summary of a speech presented at the Wind Power Construction Industry Symposium, Ministry of Power Industry]

[FBIS Translated Text]

1. The Rapid Development of Wind Power Is a Historical Task of a High Order

The Third Plenary Session of the 14th CPC Central Committee declared that establishing a socialist market economy, making system reform more thorough, and guaranteeing the sustained, rapid and healthy development of China's economy are the central tasks of China's economic efforts. In connection with these aims, the power industry's principal tasks are to effectively carry on both reform and expansion, to liberate its thinking, take a realistic attitude, and show boldness and insight, and to take increasingly effective measures for reform and opening to the outside so as to rapidly develop electric power. The development of wind power is a component of China's power industry development that must not be neglected; developing wind power in combination with other new energy sources and renewable energy sources constitutes one of China's strategies for the development of its power industry. The comrades who are involved in the power industry and the wind power industry must consciously integrate wind power into the rapid expansion of the power industry and must vigorously promote the rapid development of the wind power industry. Effective work must be done in the following areas.

- a. We must raise our consciousness and be aware of the importance of wind power.

Since the beginning of reform and opening to the outside, the electric power industry has developed rapidly. By 1992, China's total generating capacity was 165 million kilowatts and its annual output was 750 billion kWh; it ranked fourth in the world in both of these respects. China is currently adding more than 12 million kW of generating capacity a year, and the rate has been at least 10 million kW for the last five years. This is a rapid pace of expansion, but it still is not adequate for the rapid development of the national economy and the improvement of the people's condition of life. China's power shortage has now lasted 23 years and the electric power industry is still a bottleneck industry in the economy. China's per capita output of electric energy is only 646 kWh per year, which places us 80th in the world, and our use of electric power is also at a low level. In order to meet the requirement for an annual national economic growth rate of 8 to 9 percent, by the year 2000 China's generating capacity must reach 310 million kW.

China's principal energy resource is coal, but coal involves problems of environmental protection and transport. Therefore, by the next century, there must be a great expansion of hydropower, nuclear power, and wind power. The development of wind power and hydropower is well provided for in the program for the year 2050, and nuclear power too will be developed. While proceeding with economic development, adjusting our energy structure is also of strategic importance. Under these circumstances, wind power has great prospects, however, its feasibility depends on both resources and costs. Wind power is unique in cost terms; in particular, the construction times involved are short. With prices rising, with the payback problems associated with bank interest rates, and with fluctuations in international exchange rates, the unit production cost of energy is considerable. The United States is planning to continue the development of wind power which should cause the cost to fall to \$500 per kW of capacity and the price of electricity may be as low as 5 cents per kWh. This is the equivalent to about 0.5 yuan in China, which would be bearable. If we mastered domestic production of the equipment, the cost might fall even lower. The time to move ahead with wind power has unquestionably come.

While carrying out the policies of "active development of fossil-fired electric power, vigorous development of hydropower, and appropriate development of nuclear power" and "equal emphasis on development and conservation," we must be sure to make full use of China's abundant new energy resources and renewable energy resources and to accelerate their conversion to electric power in order to compensate for shortfalls. Wind power is currently the most mature of the new electric power technologies in both technical and economic terms. The development of wind power should be made the focus of the utilization of new sources of electric power and a component part of overall electric power development. Electric power departments at all levels and all units in the electric power field should include wind power on the agenda, as local conditions permit, and they should integrate it into power industry development. Programs for scientific and technical development and for product development should include the planned, deliberate establishment of wind power farms and the use of wind power equipment.

- b. The development of wind power should be linked with the peasants' progress toward comfortable conditions of life.

From the end of 1992 until October 1993, General Secretary Zhang Zemin repeatedly published major statements on agricultural matters and on work in the countryside. He said, "Without stable, all-around progress in the countryside, there can be no stable, all-around progress in society as a whole; without comfortable conditions of life for the peasants, there cannot be comfortable conditions of life for the people of the country as a whole; without modernization of agriculture, there cannot be modernization of the national

economy as a whole." Rural electrification is the material basis for agricultural modernization. Development of agricultural productive capabilities and of the rural economy, improvement of the peasants' conditions of life, and strengthened spiritual and cultural development in the countryside are closely tied to progress in rural electrification. China is a major agricultural country with a rural population of 1 billion, but 28 counties still lack electricity, 120 million people in the countryside have no electricity, and where electricity is available, its level of use is low. Nationally, the per-capita use of electricity by the rural population is only 248 kWh per year. To achieve comfortable conditions of life by the year 2000, we must see to it that no counties are without electricity and achieve 95 percent electrification of the countryside. Thus, the task of rural electrification is a difficult one; organizations at all levels and in all fields must make a concerted effort, seize favorable opportunities, accelerate progress in rural electrification, and make the fullest possible use of wind power and other new and renewable sources of energy. They must use wind power to provide electricity for farmers, stockmen and fishermen who live in border areas with abundant resources of wind energy. We should follow the example of the government of the Nei Monggol autonomous region, which undertook to provide its people with wind power and brought them both the party's concern and a modern mode of life. In order to aid poor areas by supplying them with electricity, the electric power departments must make use of wind power. The a solid provision of electricity to support agriculture and work in the countryside.

- c. Expand the use of electric power in order to help diversify the structure of the power industry

Coal is the most important of China's primary energy resources. In 1992, 75.5 percent of installed generating capacity was fossil-fired and 24.4 percent was hydroelectric, with a very small fraction of nuclear power. An energy structure with excessive emphasis on coal combustion has an unfavorable effect on the operating efficiency and reliability of the electric power system, produces transportation difficulties, and causes environmental pollution. Back in the 1960s, the United States was aware of the unfavorable human impact that resulted from an excessive reliance on coal combustion. The U.S. began to develop alternative sources of electric power and to diversify its electric power generating structure. The oil crisis of the 1970s further accelerated the use of new energy sources and renewable energy sources for power generation. Western Europe and elsewhere made major progress in diversifying their power industry structure. In California, wind power now accounts for 1.5 percent of the state's electric power output. In Denmark, the figure is 3 percent and is scheduled to reach 8 percent by the year 2000. In Germany it may reach 10 percent, and in the United

States, 3 percent. These figures show that wind power will be a component of a diversified electric power structure.

China has a variety of energy resources. In addition to abundant fossil fuels, it has renewable energy resources that are by no means negligible and that in some cases are quite significant. China's abundant hydropower, solar power, wind power, tidal power, geothermal power, and biomass power resources have a generally complementary geographic distribution, and as a consequence, their planned, deliberate development is a hopeful factor for the drafting and implementation of a strategy for diversifying China's energy structure and electric power structure; wind power and various other new and renewable energy sources promise to make these hopes a reality. Experts in energy and electric power strategy state that the 21st century will be the century of renewable energy resources. Accelerating the development of wind power and renewable energy resources in order to promote the sustained development of China's economy is the responsibility of this generation.

- d. The development and use of wind power will help improve the environment and the ecological situation.

Energy is an important aspect of social development and environmental protection. China is now in a stage of rapid economic development, and finding ways to control pollution, protect the environment, and manage the relationship between development and the environment effectively, are our current challenges. But environmental protection is not merely a national problem; it is a global problem. China is a major energy producer and consumer. It extracts and uses 10 billion tons of coal, making it first in the world in both respects. Environmental protection is one of China's fundamental national policies, and the energy-environment relationship must be addressed now. The electric power departments are fully aware of the importance of environmental protection in their industry, and for many years, despite insufficient financial resources and technological backwardness, they have made the utmost efforts to control and manage environmental pollution. Recently, we have also taken steps regarding our course of development and strategic structure, including accelerated hydropower construction, an increase in relative importance of hydroelectric power, appropriate development of nuclear power, and vigorous development of wind power, solar power, and geothermal power. We have striven to have electric power [as published] constitute a larger part of primary resource utilization.

The use of wind power promotes environmental protection. Like hydroelectric power, wind power involves no discharge of pollutants, and, in addition, it conserves coal. Therefore, the use of renewable resources and the identification of new technical measures for energy and the environment will solve the problem of limited fossil fuel resources and alleviate the environmental damage caused by large amounts of harmful substances when fossil fuels are burned.

2. Main Tasks and Requirements Regarding the Development of Wind Power

Since the 1970s, by dint of arduous efforts, China has posted outstanding accomplishments in the development of wind power. As of 1993, 120,000 miniature wind-powered generators had been disseminated through the country, representing a total capacity of 17 MW. The self-contained operation of units with capacities ranging from tens of watts to hundreds of watts has provided electricity for the essential daily needs of farmers, stockmen and fishermen in border areas, nomadic pasturing areas, and islands. In addition, more than 10 wind-power farms have been established nationwide, in such locations as: Dabancheng, Xinjiang; Jurh, Nei Monggol; Nan'ao, Guangdong; Pingtan, Fujian; and Hengshan, near Dalian. A total of 105 large and medium-size wind generators, representing a total capacity of 13.4 MW, are operating in power grids. The highest individual generating capacity currently in operation is 300 kW, but 450-kW units are now being installed. Operating experience on wind-power farms shows that this technology for generating electric power is essentially mature. The annual availability of the generating sets is about 3,000 hours. The current construction cost is about 6,000 yuan per kW, approaching that of conventional power facilities, and it is entirely possible to achieve economies of scale in the near term by expanding their use. In addition, we have created wind power research, manufacturing, design and management contingents. The current status of wind power makes it clear that China's wind power efforts are on the verge of making the transition from research to development and from demonstration projects to commercial scale. Although there have been definite achievements in China's development of wind power, there are also burdensome tasks. The principal ones are as follows—the development of wind power is not fully compatible with the development of electric power as a whole or with economic development; a favorable policy environment and development mechanism are not in existence; there is a lack of domestically produced large- and medium-sized power grid-compatible generating units needed for wind power farms; the development of wind power has not yet been incorporated into programs and plans; and there is a lack of mature experience in the construction and operation of wind power farms. Consequently, it is important that we make full use of favorable opportunities to accelerate wind power development and economic development, to build up our wind power capabilities effectively, to move the wind power industry toward a market-driven operating mechanism, and to accelerate our progress in wind power development so that we may reach new heights.

Based on electric power development needs and the particular characteristics of wind power, the principal objective in developing wind power must be considered from two standpoints. The first is the provision for a basic electric power source to areas that conventional power sources cannot reach, such as extensive, sparsely populated nomadic pasturing regions, and borderlands and isolated islands with difficult communications and complex geography. It has long been difficult to supply these areas with essential electricity generated by conventional means.

Developing miniature household wind-powered generators that will give farmers, stockmen and fishermen access to electricity is a distinctive feature of China's development of wind power, therefore, it is essential not to neglect household wind-powered generators. The other aspect is the supplementation of conventional power generation, e.g., the planned, deliberate development of wind power in regions with abundant wind resources, in a manner suited to local conditions, making it into a productive capacity that can compensate an inadequate supply of power, and the solution to the problems of low voltages on the extreme peripheries of power grids, serious line losses, and the need to adjust to peak consumption, thereby improving the quality and reliability of electric power supply in the grids. Wind power can also be combined with pumped-storage power stations in order to allow stable power generation. The concrete objective in the development of wind power is to attain a level of 1 GW by the year 2000. To meet this objective, we must concentrate on work in several areas.

- a. We must do everything possible to increase investments in wind power and to accelerate the development of wind power.

Like other types of electric power, wind power is requires extensive funds, and accelerating its development will require large investments. A comparative insufficiency of investments has long been a major problem of China's power development, and it continues to be one of our greatest difficulties. To increase the intensity of investment, we need a rational price system for electricity that will enable us to attract investors. Our experience during the period of reform and opening to the outside has made us well aware that we must free ourselves from the idea of relying exclusively on national authorities to provide electricity; we must seek investments from different channels, at different levels, and in different forms. To develop wind power, China must make thorough use of both domestic and international markets and funds, strive to assemble the funding for wind power construction from a broad range of sources, and increase the benefits obtained from the use of construction funds for wind power. Thus, while reforming the market mechanism, we must further liberate our thinking and expand our horizons, become bolder, pick up the pace, and press on undaunted with our search. We must motivate everyone, use all applicable policies, and make use of all available funds in order to accelerate the development of wind power. In addition to getting the State to provide policy investment in wind power, funding for the purpose must also be raised from other channels. In addition, we must transform the operating mechanism and provide for the use of joint ventures, joint-stock companies, and wholly owned companies in order to attract funding.

Foreign investors are now greatly interested in China's electric power market and, in 1993, investors came to China mostly to discuss joint ventures in the power industry. The electric power bureaus and power management bureaus discussed many subjects with them, and some interest was expressed in wind power; thus, there is

every possibility of starting joint ventures for the construction of wind power farms or of letting the investors build wholly owned wind power farms. All of the discussions ran into the same four questions: risk, rate of return, electricity prices, and convertibility of foreign exchange. Ultimately, they all boil down to the single issue of electricity prices. Because wind power is in its infancy and domestic production of equipment is not up to speed, the prices of wind-generated electricity will unavoidably be high. In the development stage, output will be relatively small, and this amount of power will be swallowed up in the overall grid; however, it is important to make this stage. We cannot wait for the price of wind power to come down and for production costs to decline. If we did so, we would miss a historic opportunity and we would not be able to develop rapidly. Despite the high cost, it is desirable for all the electric power bureaus and power management bureaus to make a start with wind power, then steadily upgrade the technology, increase the extent of domestic production of the equipment, bring power production up to critical mass, and reduce operating costs. Without an initial stage covering a period of 10 years or so, no industry anywhere can reach critical mass. If we do not make a start now, but wait for the next century, we will have wasted 8 or 10 years. Those who are in charge of the power industry bureaus must show some foresight. In policy terms, even though the cost of wind power is higher than other types of power, if it is spread out over the entire grid, the increase involved is a mere pittance, because the amount of electricity involved is small. This kind of support is the only way to provide a foundation for wind power and the only way to assure its large-scale development down the road.

b. We need an aggressive but realistic policy.

We must start by freeing our thinking, increasing the intensity of reform, and assigning tasks in the development and construction of the wind power industry. The electric power departments in areas with abundant wind energy must include wind power in their regional electric power development programs. Second, the programs must be realistic, scientific and rational, taking account of resource availability and demand; they must be fully thought out and include objectives, policies, and specific measures. In addition, they must be forward-moving. There must be a reasonable proportionality between initial reserves and the scale of construction. In particular, wind power resource surveys, in preparation for the construction of wind power farms, are essential and several years should be spent in gaining a clear idea of wind power resources. The preliminary work for the construction of wind power farms is extremely important, and we should not assume that developing wind power will be a simple matter. For example, the initial feasibility studies must be approached with caution. In a new undertaking, the initial results will be striking and development will be rather rapid; thus, if we have not done our work well, the rate of development of the industry will be affected.

c. Accelerate the domestic production of medium- and large-size wind-powered generators for the power grid.

To develop wind power on a large scale and to build wind power farms, we provide for the availability of generating equipment. Currently, domestic producers cannot provide mature, practicable, large- and medium-size commercial generator units. The 200- to 450-kW generators now in use have all been imported from abroad, and we must quickly arrange for their domestic production. The fastest way to increase domestic capabilities for the production of wind-powered generators is to import the technology, engage in cooperative production, and operate plants as joint ventures. We must pay attention to the scale of development and to production benefits, set up lot production rather than on-off production, and bring the factory price down. China's manufacture of wind-powered generators must adopt a competitive mechanism, steadily improving manufacturing quality, and decreasing manufacturing costs. There is extensive scope for the manufacturers and technology organizations to accelerate the domestic production and technological development of wind-powered generators.

d. Modernize conceptions, accelerate the pace of conversion to a market economy.

The development of wind power is a new undertaking in the electric power industry, and from the outset we must change our conceptions, adapt to a socialist market economy, and establish a scientific management system suited to the characteristics of wind power. In wind power construction projects, a project organization with juridical person status should be responsible for the entire process from the raising of funds to the construction of wind power farms, their operation, and repayment of loans. The wind power enterprises must institute a modern enterprise system and promote a full-scale corporation system, organizational system and management system. A wind-power pricing system which can assure that wind power can pay back principal and interest and continue to develop must be established.

As the scale of wind power development grows, the organizational and management system becomes especially important. In general, wherever funds are raised to generate wind power, with multiple investors or stockholders, limited-liability corporations should be set up; joint stock corporations are currently out of the question. The investors contribute the capital funds, and the juridical-person project management organization takes the responsibility for the entire project, from construction to operating management to sales, or the limited-liability corporation takes the responsibility for construction, operating management, and loan repayment.

e. Accelerate the formulation of wind-power policy and improve the external environment for the development of wind power.

In order to promote wind power efforts, the government must quickly draft policies for wind power development and improve the external environment. The Ministry of Power Industry's Hydroelectric Power Development and Rural Electrification Department has set up an office of new electric power generation technologies. Its functions

should be brought fully into play in planning the scale of the industry, policy management, information acquisition, organizational coordination, provision of services, and investigation and oversight. In addition, the State Planning Commission, the State Economics and Trade Commission, the State Science and Technology Commission and other departments have functions that involve the management of new energy sources. All activities that require support and coordination by the Ministry of Power Industry should receive vigorous support and coordination from within the ministry. The key matter at present is bringing a wind-power policy into being as quickly as possible. For the present, the production costs of wind power will be somewhat higher than for fossil-fired power and hydropower, and in the initial stage, the State must institute tax abatement or tax exemption policies in order to decrease the production cost; in addition, the amounts of wind power to be supplied to the power grids and the price of the electricity must be allocated within the power grids. This is the only way to promote the development of wind power. In addition, we must tighten the management of wind power, put in place an effective system of laws, regulations and management procedures, promote the development of wind power technology, devote attention to the training of personnel in the field and to the establishment of a research contingent, and engage in effective international exchange and cooperation in the technology and economics of wind power.

Rapid Development of New, Renewable Energy Resources Outlined

95P60018A Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 8 Oct 94 p 1

[Unattributed article: "Nation's New Energy Resources and Renewable Energy Resources Experience Rapid Development"]

[FBIS Summary] Beijing, 7 Oct—A State Science and Technology Commission (SSTC) official announced at a press conference today that the nation's research in and application of new and renewable energy resources are entering a period of rapid growth. The annual supply of these energy resources converts into 300 million tons of standard coal, one-fourth of China's total annual energy supply.

China's solar energy production—for ovens, water heaters, and home heating—is in first place worldwide. Domestic solar water-heater production alone has now reached an annual output of over 600,000 square meters, exceeding the annual gross output of developed nations. Domestically made new glass-vacuum-device water heaters are not only of comparable quality with foreign-made heaters, they are now mass-produced: annual output is 50,000-100,000 units. Photovoltaic technology has been incorporated in solar power stations built in Inner Mongolia, Gansu, Tibet, and elsewhere.

Wind energy resources are also continually expanding. China now has over 100,000 small-scale wind-power generators in Xinjiang, Inner Mongolia, Guangdong, and other provinces, with almost 10,000 more generators being built annually.

Biomass energy is now the chief rural energy source. Methane-generating facilities are now growing from small to medium-size and large-scale projects, and from single fuels to a variety of synthetic fuels. Commercialization of gasification and liquefaction facilities is now ongoing. Shanghai and Zhejiang Province have constructed multi-thousand-cubic-meter methane facilities whose technical standards are now world-class.

Geothermal energy application potential is enormous. For example, Lhasa's Yangbajain Power Station, with a current installed capacity of 25 MW, supplies 50 percent of the total power for the Lhasa grid. Marine energy is also growing: the Jiangxia Tidal Power Station, with a 3.2-MW generator now operational, will get a new 10-MW unit now in the preparatory construction stage. Also, hydrogen energy research is now in progress, and has been designated as a State Eighth FYP key S&T project.

Recently, SSTC, the State Economic and Trade Commission, and the State Planning Commission jointly formulated an outline for China's new and renewable energy resources development (1996-2010). This outline is designed to coordinate the nation's economic, social, and environmental forces and conditions toward greater development of these energy resources.

High-Efficiency Silicon Solar Cells With Passivated Emitter, Localized Rear Diffusion

95P60018B Wuhan HUAZHONG LIGONG DAXUE XUEBAO [JOURNAL OF HUAZHONG (CENTRAL CHINA) UNIVERSITY OF SCIENCE AND TECHNOLOGY (HUST)] in Chinese Vol 22 No 9, Sep 94 pp 1-3

[Article by Shi Jiqun [0670 3444 5028] of the Dept. of Solid State Electronics, HUST, and M. Green of Australia's New South Wales University (NSWU): "High-Efficiency Silicon Solar Cells with passivated Emitter and Localized Rear Diffusion"; manuscript received 15 Oct 93]

[FBIS Abstract] The development of a high-efficiency passivated-emitter, rear locally diffused (PERL) silicon solar cell is reported by the authors, working at the Photovoltaic Devices and Systems Research Center at NSWU. The technological preparation procedures and structural design features are described, and the mechanism for achieving high conversion efficiency is discussed. Technical measures such as passivation on both faces, localized small-area boron diffusion on the rear face, inverted pyramid structure on the front face, and zoned diffusion with light and dense phosphorus have been adopted in the design and during the preparation. Under AM 1.5 and 25°C irradiation, a photoelectric conversion efficiency of 23.8 percent—the highest conversion efficiency yet reported worldwide for a silicon solar cell—has been attained, as measured by equipment provided by Sandia National Laboratories. Other output parameters for the 280-micron-thick, 4-square-cm PERL silicon solar cell (model S 123 R) are as follows: open-circuit voltage is 696.3 mV, short-circuit current density is 42.4 mA/square cm, and fill factor is 0.8052. Figures: 2; References: 6

Blueprint Drawn for Switch to Alternative Energy
40100006A Beijing CHINA DAILY in English 8 Oct 94 p 3

[Article by Gao Jin]

[FBIS Transcribed Text] China has drafted a long-term plan on the development and use of new and renewable energy sources to reduce consumption of coal, crude oil and natural gas.

The move is also aimed at promoting a clean environment and sustained economic development.

The plan (1996-2010), drawn up by the State Science and Technology Commission (SSTC), State Planning Commission and State Economic and Trade Commission, has been submitted to the State Council for ratification.

Once approved and implemented, it will bring the use of such energy to new heights in China, said Shi Dinghuan, director of the Industrial Technology Department under the SSTC.

New and renewable energy refers to solar, wind, biomass (energy from green plants), geothermal and ocean energy.

The plan also calls for close Sino-foreign cooperation in the research, development and use of these energy sources.

Shi said all kinds of cooperation, such as bilateral, multi-lateral and regional, are welcome.

At present, China has cooperation projects with Italy, Germany, Belgium, Britain, Denmark, the Netherlands, Japan, the European Community and the United Nations.

Foreign assistance totalling more than \$60 million has been used in this field.

Since the UN Earth Summit on the environment and development was held in 1992 in Brazil, all countries have begun paying close attention to the development of renewable energy resources.

The State Council has given priority to the development and widespread use of solar, wind, geothermal and biomass energy.

China's Agenda for the 21st Century also stresses the role of new and renewable energy in sustainable economic development and environmental protection.

At present, new and renewable energy supplies one-fourth of the country's total energy. The annual amount (mainly from biomass energy) equals about 300 million tons of standard coal.

Solar energy has been widely used in China for cooking, water heating, greenhouses, satellites and telecommunications. China produces more than 600,000 square metres of solar water heating system each year, the largest in the world.

The UN has established a pilot project in Gansu Province to use solar energy for heating. And a number of solar battery cell plants with an annual output of 4 megawatts have been set up in the country.

Wind energy, now widely used in areas such as Inner Mongolia, Xinjiang and Fujian, has brought great benefits to the local people who do not have easy access to thermal and hydropower supplies.

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